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5 ENVIRONMENTAL RISK ASSESSMENT

5 - ENVIRONMENTAL RISK ASSESSMENT

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WHAT DOES THIS MODULE COVER?

The following module is intended to provide guidance for project planners and reviewers in the assessment and mitigation of environmental risk for Tidal Energy Convertors (TEC) development proposals and projects. The guidance is based on “A Framework for Environmental Risk Assessment and Decision-Making for Tidal Energy Development in Canada” developed for the Department of Fisheries and Oceans (DFO) and the Nova Scotia Department of Energy (DOE) by independent scientific experts.

This section outlines the key steps and considerations for identifying, assessing, and addressing the environmental risk of TEC projects based on the best available scientific knowledge, expert advice, and best practices for environmental risk and impact assessment. Through this guidance, project planners and reviewers can also gain insights as to:

- site-appropriate project design and size consideration,
- the type and scale of information that should be included in initial project descriptions or registration documents,
- the level and type of environmental review/assessment a project may require,
- 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
- evaluations measures or trigger points for adaptive management actions.

IS THIS MODULE FOR YOU?

This module is for anyone interested in understanding the potential environmental implications of TEC development and what can be done to assess and mitigate the environmental risks of a specific development proposal and project.

5.0 - INTRODUCTION: WHAT ARE THE POTENTIAL IMPLICATIONS OF TEC DEVELOPMENT FOR THE ENVIRONMENT?

TEC projects have the potential to cause dozens of individual and interconnected effects on the environment. An environmental effect is understood as any response or change that a project may cause in an ecological component. The following logic models (Isaacman & Daborn, 2011) were developed for the Department of Fisheries and Oceans (DFO) to illustrate the nature and breadth of the potential environmental effects. This type of model is called a Pathways of Effects (PoE). The models were developed in consultation with scientific experts from across Canada and the US.

The PoE models include the predicted stressors associated with in-stream tidal power technologies and the environmental effects they may have on specific ecological components or receptors. The six key stressors and some of their potential environmental effects are:

1. Changes in current energy: modification of water movement patterns due to energy extraction affecting sediment dynamics (alteration of substrates, sediment erosion, transport, and deposition patterns) and tidal dynamics (alteration of tidal amplitude and current velocity).

2. Effects of artificial structures: change in habitat structure and complexity, attraction or avoidance of marine life, barrier to migration.

3. Physical interactions with infrastructure: physical or physiological injury to marine organisms from passing through TEC devices (e.g. blade strikes, entanglement, pressure flux, stress, or disorientation).

4. Noise, vibration, and light emitted from devices: behavioural changes and physiological responses in marine organisms, including stress, and avoidance of habitat sites and migration corridors.

5. Emitted electro-magnetic fields: device generator and power electronics and sub-marine power cable emissions causing behavioural changes and physiological responses in marine organisms.

6. Release of contaminants: chemical pollution from paints, anti-foulants, and lubricants affecting water chemistry and marine organisms' health.

The probability and magnitude of the potential effects, if any, will vary with the specific nature of the project and the sensitivity of the ecosystem components at any given location. Thus, planners and reviewers should take all these potential interactions into consideration in the planning and implementation of TEC project proposals.

For more information on the potential environmental implications of TEC devices, see:

1. Environmental Effects of Tidal Energy Development. Proceedings of a Scientific Workshop March 22-25, 2010
http://ir.library.oregonstate.edu/xmlui/handle/1957/21617?show=full

2. Pathways of Effects for Offshore Renewable Energy in Canada
http://fern.acadiau.ca/document_archive.html?action=view&id=178.

DEFINITION: PATHWAYS OF EFFECTS

Conceptual representations of predicted relationships between the pressures or stressors created by human activities and the environmental effects they may have on ecosystem components, and in turn, the socio-cultural and economic interests and values (often termed valued ecosystem goods & services) that are linked to and rely upon them.

DEFINITION: ECOSYSTEM COMPONENT

Fundamental elements of the natural environment. Components can include wildlife, physical habitats (sediment, water, vegetation, geology), and ecosystem processes (e.g. biophysical dynamics, interactions).

To improve clarity of the Pathways of Effects (PoE) models, components have been grouped into four broad wildlife-based categories. These categories are intended to encompass physical habitats (sediment, water, vegetation, geology) and ecosystem processes (e.g. biophysical dynamics, interactions).

PLEASE NOTE:

Although they may share some similar characteristics, the design and mode of operation of TEC devices, and the consequent nature of their interaction with the environment, differ substantially from the more well-established hydroelectric and tidal barrage technologies. Due to these differences, TEC devices are expected to have less of an environmental impact.

Figures 5-1, 5-2, and 5-3 illustrate the complexity and interconnectivity of the potential environmental effects of the three main phases of a TEC development:

a) 5-1: Site Investigations;

b) 5-2: Construction, Maintenance, and Decommissioning; and

c) 5-3: Operations.

Photo Credit: Greg Trowse

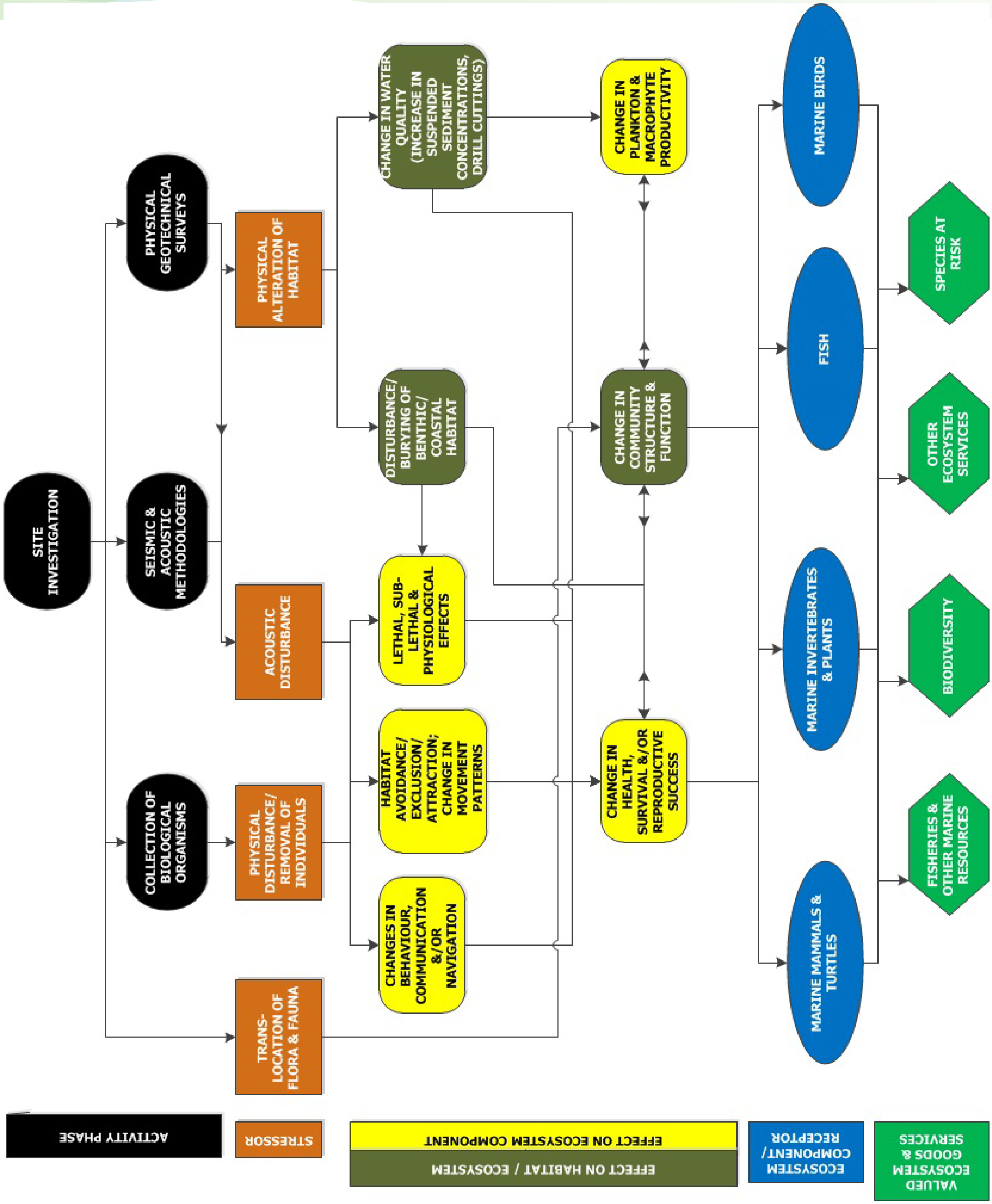

Figure 5-1: Pathways of Effects - Site Investigation

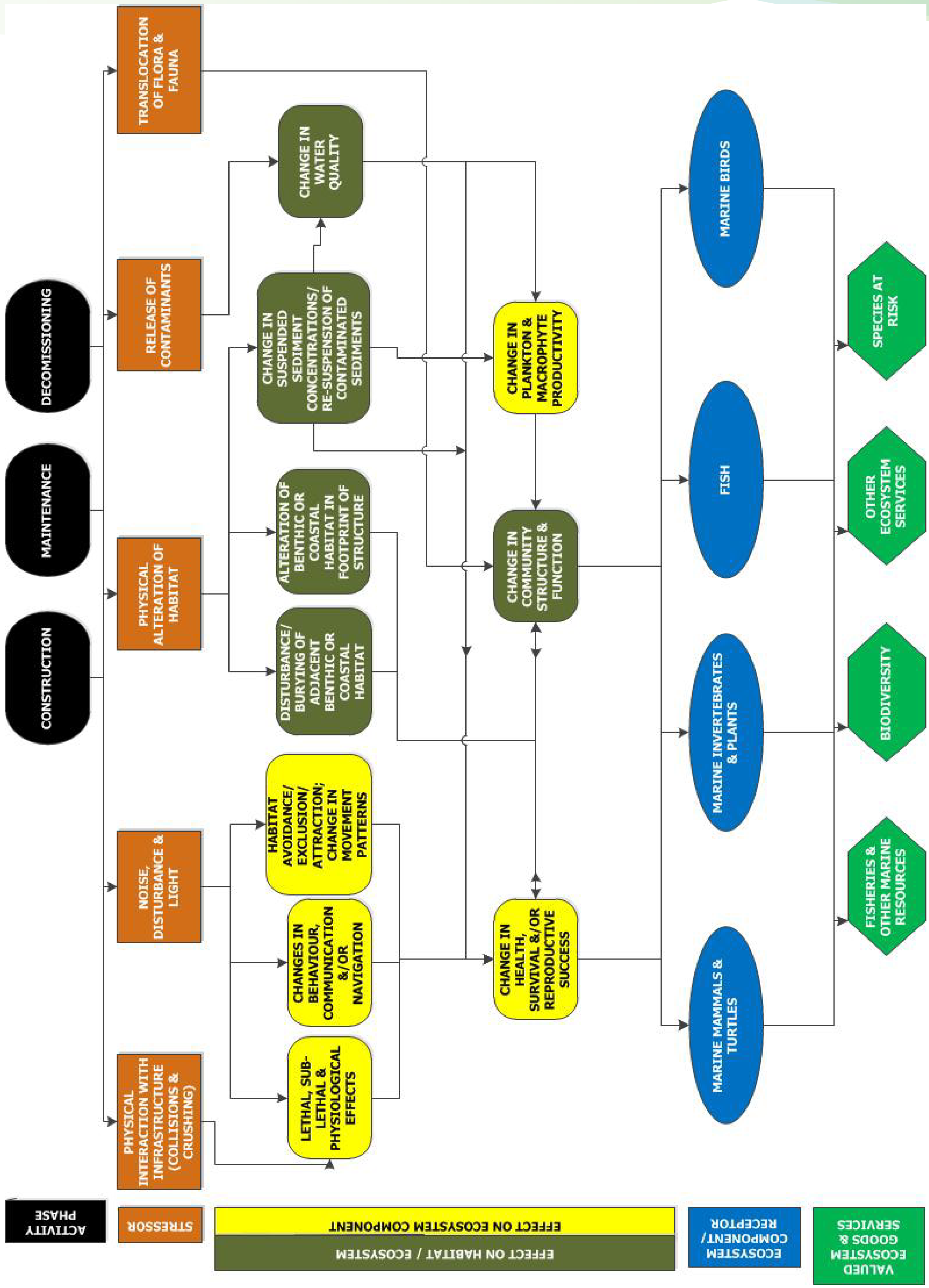

Figure 5-2: Pathways of Effects - Construction, Maintenance, and Decommissioning

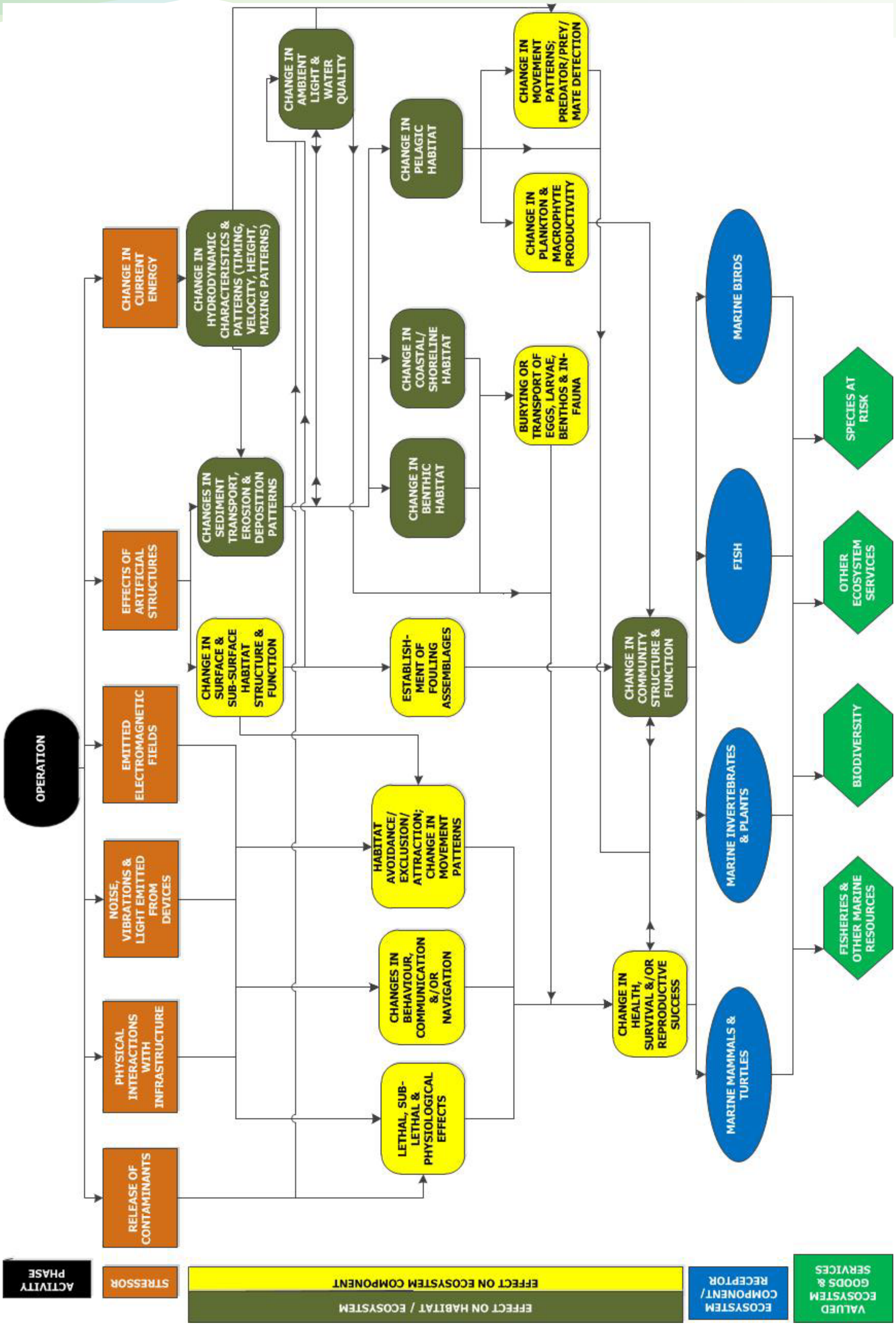

Figure 5-3: Pathways of Effects - Operations

To date, no significant impacts have been reported from any TEC development site in the world. However, monitoring results from only a few demonstration sites in the US and UK are currently available.

PLEASE NOTE:

Most of the uncertainty is associated with the operational aspects of TEC developments, which pose novel and poorly understood effects on the marine environment. The potential effects associated with site investigation and construction activities are largely comparable to those presented by other marine sectors.

5.1 - UNCERTAIN ENVIRONMENTAL RISKS OF TEC DEVELOPMENTS

TEC technologies are diverse and continue to evolve, with most still at the testing phase. As a result, there is currently a high level of uncertainty regarding the potential implications of TEC development on the biophysical environment, largely because:

- Few full-size devices have been deployed in natural environments for prolonged periods of time.
- Environmental effects are likely to be technology, scale, and site-specific.
- The most favoured locations for deployment exhibit challenging physical conditions – consequently, effective physical and biological data collection and effects monitoring are difficult and sometimes limited by the availability of suitable monitoring technology.
- There have been insufficient monitoring results to confirm predictions of environmental assessments.
- Many of the sites with high potential are insufficiently studied for the environmental implications to be assessed with confidence.

Both project planners and reviewers currently lack sufficient knowledge or experience to be able to assert, with an appropriate degree of confidence, whether a project is likely to cause adverse environmental effects. Due to these varied uncertainties, development of the tidal energy sector in Canada should proceed using a precautionary and adaptive management approach.

To date, no significant impacts have been reported from any TEC development site in the world. However, monitoring results from only a few demonstration sites in the US and UK are currently available. These monitoring programs have been short and sporadic, mainly focusing on the near-field potential impacts (in the immediate vicinity of the turbine) of a single device. The challenges of monitoring a high-energy marine environment create the need for new technologies and monitoring techniques to be employed; many of the new methods applied in studies thus far have yet to be verified as effective and accurate. While these monitoring programs provide insight into potential monitoring methodologies and help identify ecosystem components that may require particular attention, the results should not be used to draw conclusions about the general risks, nature, or magnitude of environmental impacts of TEC.

Findings of environmental monitoring programs are freely available for:

Marine Current Turbine's SeaGen Demonstration Project in Strangford Lough, Ireland (Royal Haskonings 2012).
http://seageneration.co.uk/files/SeaGen-Environmental-Monitoring-Programme-Final-Report.pdf

Verdant Powers Roosevelt Island Tidal Energy (RITE) Project in Eastport River, New York (Verdant Power 2011)
http://www.nyserda.ny.gov/Publications/Research-and-Development-Technical-Reports/Environmental-Reports/EMEP-Publications/EMEP-Final-Reports.aspx

5.1.1 - PRINCIPLES FOR OVERCOMING UNCERTAINTY

To deal with this uncertainty, the following are guiding principles for the effective and objective review of environmental risk of a TEC project. These principles include:

1. adequate consideration of ecosystem-scale and cumulative effects (see below);

2. a precautionary and adaptive management approach (see below);

3. the need for appropriate and early initiation of baseline studies;

4. the need for risk evaluation criteria and indicators that are relevant and flexible, and that can be consistently applied to projects of any type, size, or location (see below);

5. consideration of other human uses of the ecosystem (see below); and

6. early and on-going First Nations engagement (for more detail see Modules 4 and 6).

Environmental information relevant to assessing the risks associated with in-stream tidal energy developments takes a long period of time to acquire; therefore, early initiation of benchmark studies is crucial.

A basic prerequisite to making scientifically sound and well-informed decisions is the availability of information of sufficient detail and quality on the nature of the project proposal and the physical and biological environment at the site. Therefore, all project proposals **must start with a detailed project description and benchmark site assessment / characterization.** Given it is not practical to measure and monitor every parameter; the challenge is identifying the appropriate parameters to assess operation-induced change. The scope of the baseline survey requirements should be aligned with the anticipated scale of the project and its associated effects. The criterion and indicators identified below can provide a guide to potential priority parameters and benchmark surveys. Environmental information relevant to assessing the risks associated with in-stream tidal energy developments takes a long period of time to acquire; therefore, early initiation of benchmark studies is crucial.

It is well known that coastal ecosystems undergo significant changes over time, some cyclical (e.g. seasonal, annual, or multi-year) and others progressive (e.g. continuing system changes associated with sea level rise, shoreline erosion, subsidence, or human modifications such as causeways). In the face of this variability and changing environments, identifying and quantifying the effects of marine energy extraction or the direct effects of the devices on organisms is extremely difficult.

Given these circumstances, the *precautionary approach* needs to be applied to protect the environment against significant and/or irreversible damage. This approach entails a risk assessment and decision-making process that errs on the side of caution in situations where there is a lack of full scientific certainty. Notwithstanding recognition and adoption of the precautionary approach, inability to provide a complete assessment of the project and its environmental effects in the preliminary review or assessment of the proposal would not necessarily preclude the possibility of the project moving forward. Resolving gaps in scientific knowledge will require practical real-world experience, which cannot be achieved without putting devices in the water at various scales and locations.

Adaptive management is the preferred approach to dealing with projects where there is insufficient experience with the technologies, a lack of knowledge about the ecosystem for which the development is proposed, or both. In fact, the novelty and continued need for refinement of the technology makes in-stream tidal energy development an ideal candidate for a staged and adaptive development approach. Most large scale tidal developments will consist of arrays of devices that could be installed over time with some units coming on stream long before the full development is completed. The ultimate scale of a permitted project may be determined over time based on monitoring and interpretation of the results, conducted as follow-up to confirm the predictions of the environmental assessments. As projects expand to full commercial scale potential, there will be a need for continuing reassessment of the implications of the development.

DEFINITION: PRECAUTIONARY APPROACH (ALSO KNOWN AS THE PRECAUTIONARY PRINCIPLE)

This term can be defined generally as 'where there is a lack of full scientific certainty, decisions or actions should err on the conservative or cautious side (i.e., assume that an effect is more rather than less adverse)'. Please note there are many similar, but differing definitions and interpretations of this term.

The precautionary approach is a standard guiding principle in Canadian environmental policy, although its application varies among departments and jurisdictions. The 1999 Canadian Environmental Protection Act (CEPA 1999) defines the precautionary principle in slightly narrower terms as "… where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation." The principle is also enshrined, in general terms, in the 2012 The Canadian Environmental Assessment Act and in Fisheries and Oceans Canada operational policies.

DEFINITION: ADAPTIVE MANAGEMENT

A planned and systematic process for continually improving environmental management practices by learning about their outcomes. Adaptive management provides flexibility to identify and implement new mitigation measures or to modify existing ones during the life of a project. Adaptive management requires continual oversight and environmental monitoring and the ability to make modifications to projects as new information is acquired. An adaptive management plan should be a requirement for project approvals, with procedures that enable rapid responses when and where an effect is detected.

ADAPTIVE MANAGEMENT IN PRACTICE

Author: Monica Reed

Adaptive management measures are often part of the Environmental Assessment (EA) process in Canada. Although the 2012 Canadian Environmental Assessment Act does not contain specific requirements that pertain to adaptive management practices, follow-up programs often incorporate adaptive management measures. Depending on the nature of the project, either the review panel or the responsible authority determines if a follow-up program is mandatory for a project. Adaptive management is implemented in follow-up programs in order to provide flexibility to identify and implement new mitigation measures or to modify existing ones in light of real-world experience. Given the continually changing environmental conditions and scientific uncertainties associated with in-stream tidal energy development, developers require the ability to modify monitoring studies and mitigation methods as experience is gained. In the US, Ocean Renewables Power Company (ORPC) in Maine has developed an adaptive management plan for their Cobscook Bay Tidal Power Project, as required by their U.S. Federal Energy Regulatory Commission (FERC) pilot project license. An Adaptive Management Team has been created to implement the adaptive management plan, which has been defined as "A collaborative, consultative process among ORPC management, state and federal agencies, and stakeholders that monitors and reviews the results of policies, project actions and environmental data, and integrates this new learning into policy and management actions, adapting as necessary"(ORPC, 2012).

Cumulative effects represent another element that requires adaptive and continual reassessment. Follow-up must recognize that small, possibly incremental changes to critical ecosystem processes may not be evident for a long time after completion of the array, although such changes may well affect critical aspects of the environment (e.g. habitat) or progressively interact with other established resource uses. These additional elements of uncertainty require that any established commercial-scale development be reassessed at intervals of time over the life of the project.

DEFINITION: CUMULATIVE EFFECTS

Additive or multiplicatory effects of a project or activity on the environment when the effects are combined with other past, present, or future human activities. These activities may be taking place within the same ecosystem or affecting the same ecosystem component (e.g. migratory species) that may move between ecosystems and be subjected to more than one development.

5.2 - STEPS TO PLANNING FOR AND ASSESSING THE ENVIRONMENTAL RISKS OF A PROPOSED PROJECT

Project planners and reviewers should follow the steps provided below (Figure 5-4: Framework to Reduce Risk):

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.
4. Identify risks of interference with other human uses of the ecosystem (e.g. fisheries, recreation).
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, when applicable.
7. Prepare the environmental monitoring and follow-up activities, and an adaptive management program for an approved project.

In the Framework to Reduce Risk (Figure 5-4), socio-economic assessment /stakeholder consultations are shown as a step in the framework. The dashed line indicates that this process is not a strict requirement of environmental assessment and is often external to the environmental assessment process. It is included because it is recognized as an important component of the assessment process; however, the focus of this framework is on environmental assessment.

Photo Credit: Greg Trowse

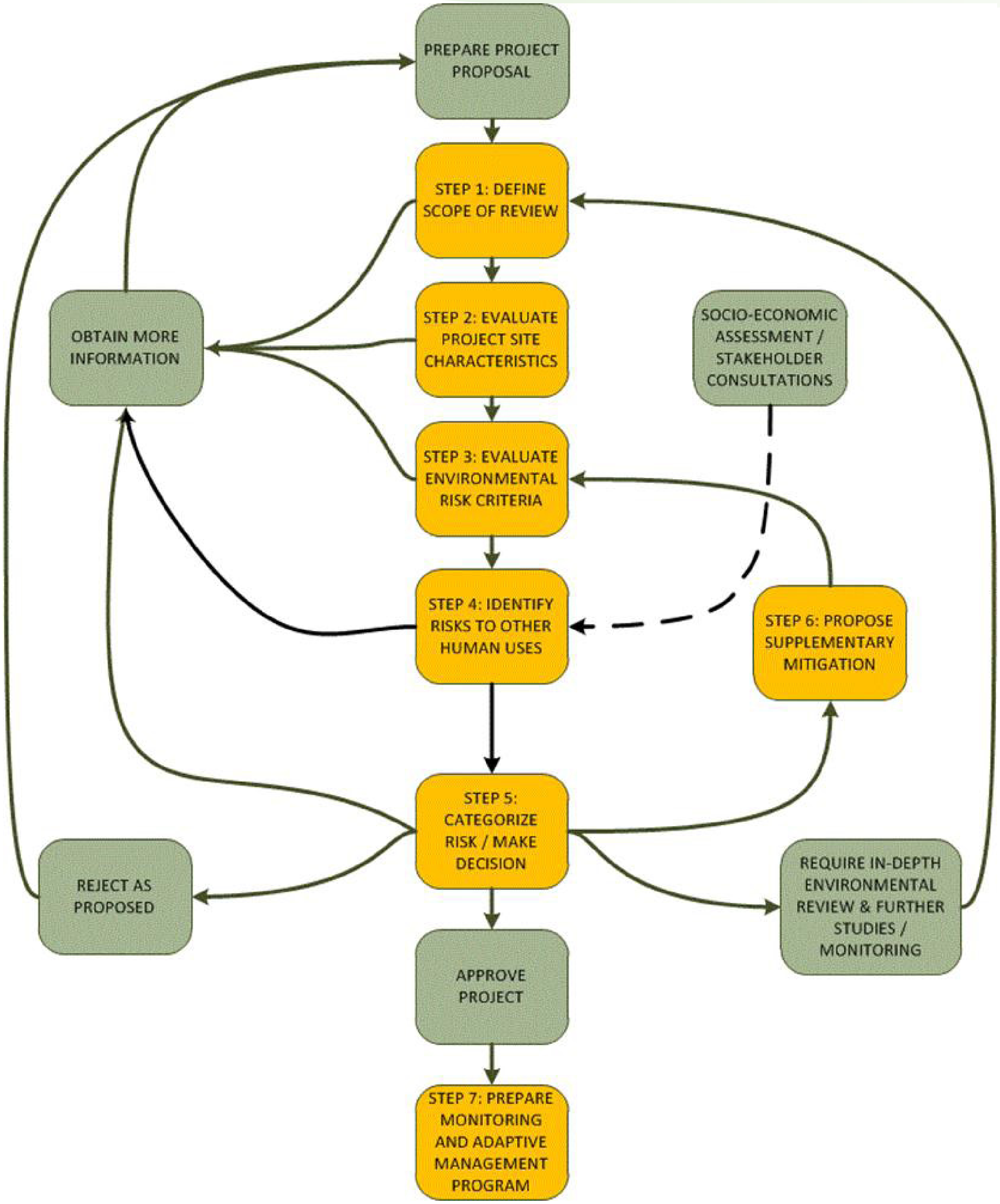

Figure 5-4: Framework to Reduce Risk (Isaacman, Daborn & Redden, 2012)

DEFINITIONS: MARINE LIFE

Planktonic organism - any organisms that live in the water column and are incapable of swimming against a current.

Benthic – refers to the bottom of a body of water (i.e. seabed) and to the organisms living in or on it.

Pelagic – refers to the zone above the seafloor, including the water column up to the surface.

5.2.1 STEP 1: DEFINE THE SCOPE OF THE REVIEW

5.2.1.1 - WHAT ACTIVITIES SHOULD BE COVERED?

It is important to plan for and mitigate environmental risks occurring throughout the life of the project from initial site investigation (baseline studies) to construction to operations to decommissioning. The environmental risks associated with site investigation, construction, maintenance, and decommissioning activities, as well as the potential releases of chemical contaminants (e.g. anti-foulants, lubricants), should be consistent with those typical of most marine in-water activities. Both the risk and mitigation options are fairly well understood by those experienced with marine development. By following the generally-accepted guidelines and best practices for these types of in-water activities, the environmental effects from these activities should be adequately mitigated and do not require further review.

However, the risks related to the presence and operation of a TEC development are novel and poorly understood and cannot be adequately addressed using current procedures and best practices. Thus, a review of these risks is necessary prior to the approval and implementation of any project.

Developers have a stewardship responsibility to ensure their projects do not cause a significant adverse change to the environment.

5.2.1.2 - WHAT PROJECTS SHOULD BE REVIEWED?

Scientists and regulators have generally considered small-scale, short-term deployments (e.g. single device prototype or pilot trials) to present a fairly low environmental risk that could be addressed by application of standard mitigation measures, especially given the option to cease operations if a problem becomes detectable. However, at least until more knowledge and experience are gained on the interactions of moderate- to large-scale devices or multi-device arrays with the environment, any demonstration or commercial scale deployments should undergo, at minimum, a preliminary review and risk assessment, following the framework prescribed below.

5.2.1.3 - FOLLOW AN ECOSYSTEM APPROACH

Developers have a stewardship responsibility to ensure their projects do not cause a significant adverse change to the environment. This includes both direct effects on a population, species, and habitat and broader-scale effects on dynamic ecological functions and processes that are critical to the ecosystem's role in a larger coastal context.

While a thorough examination of every ecosystem component may not be practical or warranted, a proper risk assessment must recognize the complexity of the interconnections among and between species and the physical environments. Following an ecosystem approach, the review should cover the following:

- fish;
- marine mammals;
- marine plants and invertebrates, including shellfish, crustaceans, and planktonic organisms;
- marine birds; and
- the biophysical habitats and ecosystem processes upon which the species depend.

All life stages (e.g. eggs, larvae, juvenile, and adult stages), as well as populations, should be considered. Habitat is defined broadly as the benthic, pelagic, shoreline and/or surface areas, and the physical, chemical, and biological conditions, on which individual species depend, directly or indirectly, including the following:

- spawning, nursery, rearing, or food supply areas;
- migratory routes;
- refuges from predation (e.g. seaweed beds, marshes, etc.); and
- biological community and food-web structure and interactions.

5.2.1.4 - SPATIAL SCOPE

A key aspect of the environmental review of a tidal project is defining the geographic scope of the affected area. Due to the nature of in-stream tidal energy, the scope of the affected area may extend well beyond the area of direct physical occupation of infrastructure such as, direct and indirect effects on flow characteristics and marine life. Therefore, it is important to consider both localized (near-field) and system-wide (far-field) effects (Table 5-1). While information may be insufficient to accurately define the entire extent of affected area, a conservative and scientifically justifiable approximation must be considered when assessing each of the criteria.

While a thorough examination of every ecosystem component may not be practical or warranted, a proper risk assessment must recognize the complexity of the interconnections among and between species and the physical environments.

DISCUSSION: CONSIDERING THE WHOLE ECOSYSTEM.

Please note that while federal and provincial regulators may be primarily concerned with certain species or habitats of social or economic importance (such as commercially valuable fish species, marine mammals, or species at risk), legislated review and permitting processes (e.g. under the Fisheries Act, Canadian Environmental Assessment Act, and provincial environmental assessment acts) recognize the need to consider the effects on the whole biological community, as well as the physical habitats on which they depend.

Table 5-1: Examples of Near Field and System-wide Environmental Effects

EXAMPLES OF NEAR FIELD AND SYSTEM-WIDE ENVIRONMENTAL EFFECTS		
RISKS	POTENTIAL NEAR FIELD EFFECTS	POTENTIAL SYSTEM-WIDE EFFECTS
Effect on Water Movement and Sediment Dynamics	Change in hydrodynamic characteristics and patterns in close proximity to TEC device altering local sediment dynamics (scour, sediment deposition, and erosion).	Change in regional and/or coastal/shoreline habitat due to alteration of sediment dynamics (transport, erosion, and deposition pattern) and tidal processes (timing, height, mixing patterns, current velocity).
Extent of Habitat Alteration Due to the Presence of Physical Infrastructure	Change in benthic habitat composition and complexity due to scour and presence of device base and submarine cables.	Change in biological community structure and function with trickle down ecosystem effects.
Physical Obstacle to Marine Organisms	Physical interaction with device or stress induced by pressure flux causing injury or death of marine organisms.	Impact on the stability and dynamics of the local population, with possible trickle down effects on local, regional, and potentially remote population and biological community structure and function.
Noise, Vibrations, and Turbulence Effects on Marine Organisms Due to Turbine Operation	Alteration of marine organism behaviour (e.g. habitat avoidance, change in movement patterns, decreased mate and prey detection).	Impact on the stability and dynamics of the local population, with possible trickle down effects on local, regional, and potentially remote population and biological community structure and function.
Effects of Other Signals Emitted by Project Infrastructure	Electromagnetic field and artificial light resulting in stress, physiological damage, and behavioural changes (avoidance/attraction, communication, movement patterns).	Impact on the stability and dynamics of the local population, with possible trickle down effects on local, regional, and potentially remote population and biological community structure and function.

5.2.1.5 - **CUMULATIVE EFFECTS**

It is highly probable that successful deployment of devices will stimulate further tidal developments within the same tidal energy resource area. Cumulative effects have always been difficult to forecast. Most oceanographic relationships are non-linear, so that modification of one parameter (e.g. current velocity) may result in a magnified change in related parameters (e.g. turbulence, water column mixing, etc.), producing system-wide changes that may seem out of proportion to the original disturbance.

All proposals should be evaluated in the context of other established or projected human activities in the affected area. For example, while a given turbine or array may be expected to result in only a minor reduction in tidal energy or affect only a small fraction of habitat in the system, many activities (tidal or other) acting in concert (cumulatively or synergistically) may result in major changes to the tidal ecosystem.

Specifically, consideration of cumulative effects should include the following:

- regional system-wide effects (i.e. other than just local, direct effects);
- effects during a longer period of time into the past and future; and
- effects on ecosystem components due to interactions with other past, existing, and future (e.g., reasonably foreseeable) activities, and not just the effects of the single project under review.

For more guidance on this topic, see Cumulative Effects Assessment Practitioners Guide. http://www.ceaa-acee.gc.ca/default.asp?lang=En&n=43952694-1

5.2.1.6 - TIMESCALE

Effects may change, intensify, or only become detectable over a period of time. Thus, effects should be assessed over the entire predicted life of the project.

5.2.1.7 - STAGED DEVELOPMENTS

Although proposals for single or small-scale devices or demonstration projects may not exhibit a high risk or trigger environmental assessment requirements, proponents and regulators should keep in mind any intentions for expansion (scaling-up) of the project, as larger, longer-term projects will present different environmental risks in a given area. By considering projected scale-ups in the review of early phase proposals, regulators and proponents can be better prepared to address potential future environmental concerns, including preparation of adaptive management strategies and initiation of data collection and monitoring programs. This consideration would permit a streamlined and progressive environmental assessment process in the event that an expansion is pursued.

5.2.2 - STEP 2: EVALUATING THE PROJECT SITE CHARACTERISTICS

5.2.2.1 - SITE SCALE RELATIONSHIPS

Assessing the implications of TEC developments requires recognition of the important interrelationship between the scale of the development and the size and characteristics of the site itself. TEC developments require high flow locations. Strong current flows, sufficient for renewable energy extraction, are found in three different situations: through the narrow entrance of a coastal basin, through multiple passages between landforms, and in certain coastal areas offshore (Figure 5-5).

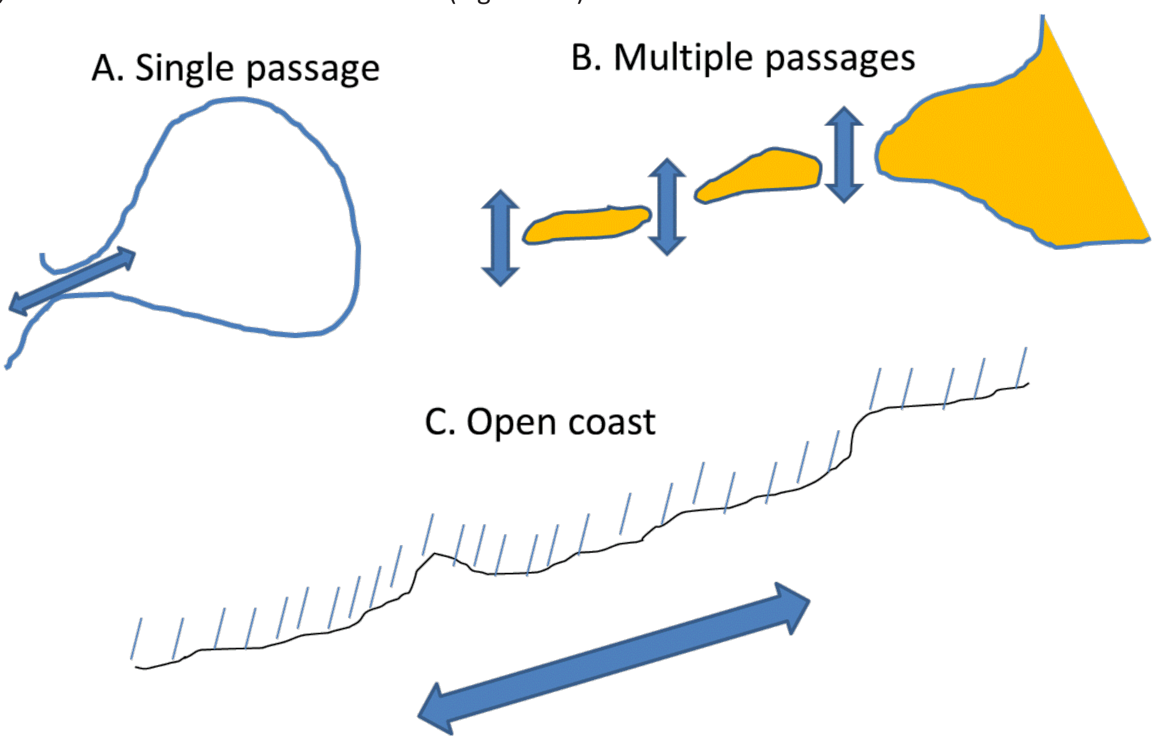

Figure 5-5: Types of Tidal Energy Sites

The environmental effects of energy extraction in these three situations differ significantly, as discussed below.

A. SINGLE NARROW PASSAGE

The confined entrance to a basin or bay represents the only passage through which water and migrating animals can pass. TEC devices will resist and divert flow into and out of the basin, resulting in increasing elevation differences (and hence faster flows up to a point – cf. Garrett & Cummins, 2008) on either side of the passage, until increasing friction begins to limit flows and therefore, decrease kinetic energy. As the scale of development increases relative to the width (scale) of the passage, a TEC array would begin to act more like a barrier, affecting the tidal resonance and hence, the amplitude as well as the phase of the tide. In general, a basin entrance location is more likely to produce system-scale effects than either inter-island or coastal locations. The problems for organisms are varied: decreasing water velocity behind the array would be expected to affect sediment erosion and deposition, and hence, benthic habitat and biota in the bay; migrating fish have no alternative but to pass through the passage, and as the scale of the development increases, this will represent an increasing risk of encountering the devices; and noise and turbulence in the passage will change, with consequent effects on animal communication, prey/predator detection, etc.

B. MULTIPLE PASSAGES BETWEEN LANDFORMS

Canada's three ocean coasts exhibit numerous sites with multiple high flow passages between islands and other landforms. Because there are alternate pathways that the water can follow, the restrictive effects of TEC devices will be different: increasing resistance to flow will mean that more water will pass through other open passages. Similarly, tidal amplitudes, flow velocity, and resonance relationships are likely to be less affected than in a single narrow passage site. Whether any alternate passages can be used by migrating animals will depend upon local circumstances (e.g. water depth, current velocities, etc.) and perhaps also on stock genetic characteristics that might determine migratory route.

C. OPEN COAST

By comparison, open coast sites with high current speeds exhibit few of the above interrelationships. Increasing array size will have much less effect on flow dynamics or tidal characteristics, and animal movements will be far less restricted. For the biota, the localized effects (e.g. entrainment, benthic and pelagic habitat characteristics, noise and turbulence, etc.) are likely to be of greatest importance.

5.2.2.2 - PRESENCE OF SPECIES AND/OR HABITATS OF HIGH CONSERVATION CONCERN

Projects proposed to take place in an area containing one or more ecosystem components (species or habitats) of high conservation concern (HCC) should automatically be flagged as potentially high risk.

HCCs are more susceptible to being significantly and adversely affected by added stressors and less capable of recovery (low reversibility). Thus, there would be higher consequences to assuming risks from the project. For a project to be approved or permitted to continue, adequate mitigation measures must be put in place to ensure no adverse impacts to HCC.

DEFINITION: HIGH CONSERVATION CONCERN (HCC)

A habitat or species of HCC are ecosystem components that are considered to be of ecological, economic, or cultural concern or are sensitive to disturbance. Valued Ecosystem Components is the more commonly used term in environmental assessment to signify this type of habitat or species.

Table 5-2: Species and Habitats of High Conservation Concern

SPECIES AND HABITATS OF HIGH CONSERVATION CONCERN		
HCC		**EXPLANATION**
Species - resident or seasonal	Federally or provincially listed Species at Risk, their residence and/or critical habitat.	Species at Risk are protected under federal and/or provincial Species at Risk legislation. Given they are already vulnerable and at low numbers, the loss or disturbance of even one or small number of individuals can be significant and thus pose unacceptable consequences to the survival of the species. Many Species at Risk require specific habitat conditions; such species will be more sensitive to changes caused by TEC developments and thus risks may be higher.
	Non-listed species that are at risk or regionally rare	Although not listed under legislation, many species have been identified as at risk or rare through various national or international scientific assessment bodies like Committee on the Status of Endangered Wildlife in Canada (COSEWIC) or International Union for Conservation of Nature (IUCN). Given they are already vulnerable and at low numbers, the loss or disturbance of even one or a small number of individuals can be significant and thus pose an unacceptable consequence to the survival of the species. Many species at risk require specific habitat conditions; such species will be more sensitive to changes caused by TEC developments and thus risks may be higher.
	Species harvested in commercial, recreational, or aboriginal fisheries	Harvested species may be less able to tolerate the added stressors from tidal developments. Moreover, changes caused by tidal developments may affect the productivity and sustainability of fisheries and thus will be under a higher level of public scrutiny. It should also be noted that commercially important species may be harvested in regions well away from the spawning or rearing habitat where the tidal developments may occur.
	Marine mammals, sea turtles, and other species of high public concern	Whether or not considered at risk, many species may be highly valued by the public and the loss or disturbance of even one individual may be deemed unacceptable. Where these species are present, a proposed project will be under greater public scrutiny.
	Migratory species (especially those that cross international boundaries)	Species that migrate between habitats may be subject to additional stresses. There may also be legal implications if a species crosses an international boundary between feeding and spawning habitats.
	Species known to be highly sensitive to disturbance.	Some species have limited tolerance to changes in environmental parameters (e.g. temperature, turbidity, etc.); such species will be more sensitive to changes caused by TEC developments and thus risks may be higher.
Habitat	Habitat of listed or unlisted, at risk or rare species	Areas designated as residences or critical habitats for species at risk are protected under provincial or federal legislation. Whether legally designated or not, risks to the essential habitat of an at-risk or rare species need to be minimized to ensure the survival of the species. Rare or uncommon habitats are often important to rare or uncommon species, and therefore, are of concern for conservation of biodiversity.
	Ecologically significant or rare ecosystems	Some areas may be regionally, nationally, or internationally recognized and thus any activities in those areas would be under high public scrutiny (e.g. marine protected areas). By definition, ecologically significant areas have a high ecological value, in terms of providing valuable ecological services, supporting high levels of biodiversity, or containing unique or rare features or species. They are often also more sensitive to perturbation. Even a small loss or disturbance of an ecologically significant or rare ecosystem can have significant consequences.
	Regionally uncommon habitat that is essential for one or more species	Even where the habitat is not considered rare, it may be regionally uncommon. Local populations that depend on these habitat conditions may be harmed if they do not have access to other areas of similar habitat in the region.
	Habitats highly sensitive to perturbation	Habitats characterized by soft or loose sediments are more prone to sedimentation and erosion as a result of changes to current flows, turbulence, or water column mixing, with consequent effects on the biota. Moreover, some habitats are sensitive to changes in tidal range, such as seagrass, macro-algae (seaweed) and salt marshes, which may be present in lower flow environments within the system-scale affected area.

5.2.3 - STEP 3: EVALUATING THE ENVIRONMENTAL RISK

Planning and regulatory decision-making (e.g. approval or rejection, degree of environmental assessment) is made easier when the indicator(s) or thresholds of risk can be expressed in quantitative terms. For example, the current regulatory thresholds for tidal energy projects for deciding whether a given proposal requires a limited or full environmental assessment are based on total energy production capacity (5MW for a Comprehensive Study under the CEAA and 2MW for Class 1 environmental assessment in Nova Scotia). However, these values are essentially arbitrary and do not necessarily reflect the potential that the project may cause significant adverse damage to the environment. For example, thresholds based on energy production, or size of the project, are what are typically used for other types of energy projects. However, these criteria considered in isolation from the physical and biological characteristics of the proposed site are inadequate, by themselves, to reflect the environmental risk or impact of a project. For example, the impact of a 2MW array in an open high energy site, without sensitive habitats or species, may be low, whereas the same 2MW array may have a significant impact in a semi-enclosed or lower energy site or area with sensitive species or habitats.

Because of the rapid development of this field, the highly variable nature of the environment and technologies, the limited knowledge of ecosystems, and the complex scale relationships (e.g. device/array scale vs. site scale), it may not be scientifically justifiable to select any one meaningful and durable universally applicable threshold for decision-making.

5.2.4 - MULTI-CRITERIA APPROACH

To overcome the above mentioned challenges, an approach based on multiple qualitative and numerical science-based evaluation criteria and indicators of risk, which are adjustable to particular project designs and sites, is recommended.

The following section offers a set of science-based criteria and indicators that:

- are relevant, flexible, and can be consistently applied to projects of any type, size, or location;
- address directly or indirectly the major environmental concerns related to the operation of in-stream tidal devices;
- relate to specific and characterizable attributes of a development project and the environment; and
- are based on best available scientific knowledge.

In cases of uncertainty, the risk evaluator should err on the side of precaution, and either request more information from the proponent or rate the criterion as higher risk.

While it may not be possible to make a thorough and individualized risk evaluation for each species or habitat (due to lack of resources or knowledge), a generalized assessment needs to be made based on the best available information on the types of species and habitats present. Given the higher concern and risk, it may be reasonable to focus the review on HCC species and habitats. Risk levels associated with each indicator should be based on the attributes of the forecast effect listed in Table 5-3.

PLEASE NOTE:

Whether or not HCC components are likely in the affected area, risks to ecosystems and marine organisms are present and potentially significant. Even where HCC components are present, a project may not be considered a high risk if none of the criteria fall outside acceptable parameters. Conversely, a project in which a criterion has been flagged could be considered a high risk even if no HCC components are present.

Table 5-3: Attributes of the Forecast Effect upon which to Assess Indicators

ATTRIBUTES OF THE FORECAST EFFECT UPON WHICH TO ASSESS INDICATORS	
CHARACTERISTICS	**NATURE OF THE FORECAST EFFECT**
Probability	What is the likelihood of the stressor or effect occurring?
Detectability	1. Magnitude of the anticipated impact. Is the effect forecast to be within detectable levels? 2. Measurability. Is it directly or indirectly measurable using currently available tools?
Spatial extent (near and/ or system-scale)	Variability in effects throughout the entire affected area should be recognized.
Significance	To the species, population, habitat, or ecosystem (e.g. how sensitive is the receptor to changes, are the consequences ecologically acceptable?).
Duration	Most operational effects should be considered long-term (for the duration of the project) or permanent.
Reversibility	This is the ability of the ecosystem component to recover (return to approximate pre-development conditions) once the stressor is removed. It is not a measure of whether the stressor itself can be removed. Some effects may be reversible if detected and appropriate actions (e.g. mitigation, cessation of operations, and removal of structures) are taken in a timely manner. Others may be irreversible, such as destruction or harm to rare or at risk species or habitats. Even where direct effects are reversible once a stressor is removed (e.g. the effect on hydrodynamic and sediment processes and patterns due to removal of tidal energy), it may not be possible for habitats, populations, or community structure to recover from long-term changes (i.e. to return to previous conditions).

Photo Credit: Greg Trowse

5.2.4.1 - CRITERION 1: EXTENT OF HABITAT ALTERATION DUE TO THE PRESENCE OF PHYSICAL INFRASTRUCTURE

This criterion addresses the physical effects of infrastructure on the habitat within the 'localized' area of the project. This includes the physical space of benthic, pelagic, and coastal habitat occupied, or directly affected by, the physical infrastructure, including cables and inter-structure gaps.

Table 5-4: Criterion 1 - Extent of Habitat Alteration Due to the Presence of Physical Infrastructure

CRITERION 1 INDICATORS OF RISK	
INDICATORS	**EXPLANATION**
Physical presence of infrastructure on Benthic (seabed) habitat	**Alteration could include:** • Physical loss of habitat of a particular type (e.g. covering, clearing, smothering, or flattening); • Change in the composition (e.g. hard versus soft-sediments) and complexity of the habitat. This may result in a change in the biological community, especially in areas with soft-sediments, vegetation, and/or homogeneous habitats; and • Potential for erosion and/or sedimentation. Are structures placed on soft or loose sediments vulnerable to erosion / scour around the bases of structures? Are any mitigation measures in place to address this issue? Is it possible to forecast the fate of sediments mobilized by the infrastructure? Will scouring be continuous or progressive during the existence of the project?
Physical presence in the water column	**The structure may:** • Create an obstacle for some organisms; • Serve as an artificial reef or aggregation device for some organisms; • Provide surfaces for macro-algae (seaweed) and invertebrate colonization, especially where sheltered from strong currents (These may include alien species); and • Cause wake / turbulence effects.
Physical presence on the surface	**Some technologies may have components at the water surface. The increase in structure may:** • Create an obstacle for some marine mammals or seabirds; • Act as an aggregating device or provide haul-out or roosting surfaces; • Provide surfaces for macro-algae and invertebrate colonization; and • Affect light levels penetrating through water column.

5.2.4.2 - CRITERION 2: EFFECT ON WATER MOVEMENT AND SEDIMENT DYNAMICS

Table 5-5: Criterion 2 – Effect on Water Movement and Sediment Dynamics

CRITERION 2 INDICATORS OF RISK	
INDICATORS	**EXPLANATION**
Amount of kinetic energy expected to be extracted by the project compared to the total available kinetic energy in the system (percentage).	The intent is to compare the amount of energy being removed from the system with that required to maintain natural processes and patterns. The higher the percentage, the greater the likelihood to cause noticeable changes to localized, and/or system-scale water and sediment dynamics.
Physical configuration of the site in which the development is to be located (site-scale relationship).	The project might be placed in a single narrow passage (entrance to a basin), a multi-passage system, or open coast environment. (See 5.2.2.1 Site Scale Relationships). Each type of site may experience different localized and regional system-scale changes due to resonance effects, turbulence, and proximity to coastlines. The size and configuration of the development needs to be scaled to the type of site.
System characterized by seasonal or spatial fluctuations in natural flow patterns that may be affected by a regulation or disruption of current flow.	The intent is to identify the degree of dependence of ecosystem processes and species on seasonal and spatial fluctuations and variability. This acts as a qualitative measure of the significance of forecasted change in tidal energy and associated processes.
Other TEC developments, in operation or planned, in the system (cumulative effects).	The proposed reduction in tidal energy of the present proposal should be considered in combination with that of the other developments to address the potential for cumulative or synergistic effects.

5.2.4.3 - CRITERION 3: TIMING OF SHORT-TERM PROJECTS

This criterion seeks to account for changes to time and season sensitive habitats and species.

Table 5-6: Criterion 3 -Timing of Short Term Projects

CRITERION 3 INDICATORS OF RISK	
INDICATORS	**EXPLANATION**
Timing of project activities in relation to known spawning, nursery, migratory, or other critical time periods.	Where projects will be in place for less than one year, the intent is to ensure that the potential risks from short-term deployments (e.g. demonstrations or trials) are not discounted due to their temporary nature. While the stressor may be temporary, long-term and population-scale effects may be possible.

5.2.4.4 - CRITERION 4: PHYSICAL OBSTACLE TO MARINE ORGANISMS

This criterion is intended to serve as a measure of:

A. the potential of injury or mortality to organisms from collisions with (e.g. blade strikes or encounters with cables) or passing through (e.g. entrainment in downstream turbulence or pressure effects) project infrastructure; and

B. the potential of the project to impede natural movement or migration patterns, either through (A) or active avoidance.

Table 5-7: Criterion 4 –Physical Obstacle to Marine Organisms

CRITERION 4 INDICATORS OF RISK	
INDICATORS	**EXPLANATION**
Capability of marine organisms to Detect and actively avoid the array	This is intended as a measure of the risk of injury from physical interaction with project infrastructure that is applicable regardless of the characteristics of the specific type of device or array. This measure is based on the assumption that passing through the site occupied by the turbine (localized) increases the risk of physical or physiological injury. Signals produced by the devices, including visual, noise, vibrations, electromagnetic field, and turbulence may enhance their detectability by marine organisms and thus reduce the potential for physical encounters. This is only the case for organisms able to take evasive actions and/or take another route. Some organisms may be stronger or more agile, able to overcome currents and swim around multiple obstacles, while weaker swimmers or non-motile organisms (that travel with the currents) may be unable to avoid entrainment or navigate through complex obstacles. Given that the ability of many species and life stages to detect and avoid these devices is poorly understood, this indicator, should at minimum, be based on the general understanding of swimming ability and behaviours, where known. Please note, the signals emitted by the device(s) may be far-reaching and thus affect the movements and behaviours of organisms well beyond the localized area. Moreover, these signals may have negative consequences for organisms unable to avoid the affected area (see Criterion 5 and 6).
Proportion of the specific pathway occupied by the project	This is a measure of whether the project presents a total or partial obstacle to the use of the particular route in which the project is located. Given the above, will the species be able to follow their natural migration route / movement pathway without having to pass through the array (i.e. is there available and suitable space to go around it)? Both the horizontal (e.g. width of the channel) and vertical range (depth in the water column) must be considered.

CRITERION 4 INDICATORS OF RISK	
INDICATORS	**EXPLANATION**
Presence and suitability of other natural pathways available to the population to move between habitats	This is a measure of how important the specific pathway in which the project is to be located is to the population and the ability / probability of individuals and/or the entire population to take an alternate route. An example may be where the project is placed in one of multiple channels in the system (see 5.2.2.1. Site Scale Relationship). However, in this case, it should not be assumed that all the channels may serve as suitable routes. Some considerations include: • The frequency of use of the route and its alternatives by each population. o Is the project placed in the primary or a less frequented route? • Are individuals strongly predisposed (e.g. genetically or behaviourally) to prefer one route over another or are they equally likely to take more than one route? • Capability of marine organisms to actively avoid the array (see above). • Are the alternate routes capable of supporting a higher level of traffic and/or could there be a cost to concentrating movement through fewer routes (e.g. increased competition, risk of predation)?
Presence of other developments in the area that may also present an obstacle to movement of marine organisms (cumulative effects)	Either within the particular pathway or within alternative routes.

5.2.4.5 - CRITERION 5: NOISE, VIBRATIONS, AND TURBULENCE EFFECTS ON MARINE ORGANISMS DUE TO TURBINE OPERATION

The intent of this criterion is to serve as a measure of the likelihood that noise, vibrations, and/or turbulence produced by the operation of tidal turbines will adversely affect the behaviour or physiology of marine organisms.

Responses to noise and vibrations could include the following:

- avoidance of affected areas (may exclude a species from habitat or be a barrier to movement);
- interference with navigation or orientation mechanisms/cues;
- increased stress;
- interference with communication, and mate and prey detection; and
- physical or physiological damage to auditory systems.

PLEASE NOTE:

While the intensity may be highest in the immediate vicinity of devices, noise and other disturbances emitted by devices may be detectable well beyond the immediate location of the project, producing potentially adverse behavioural and physiological responses to sensitive species at some distance from the actual project site. Thus, reviewers should consider the detectability and reactions of organisms present in both the localized and system-scale area.

Where solid data are too limited for reliable estimates to be made, a generalized, qualitative comparison should be made.

Table 5-8: Criterion 5 – Noise, Vibrations, and Turbulence Effects on Marine Organisms due to Turbine Operation

<table>
<tr><th colspan="3">CRITERION 5 INDICATORS OF RISK</th></tr>
<tr><th>INDICATORS</th><th>NOISE AND VIBRATIONS</th><th>TURBULENCE</th></tr>
<tr><td>Predicted noise and turbulence output generated by devices at the specified scale of development (i.e. actual size of devices, number of turbines, and associated infrastructure)</td><td colspan="2">A valid estimate based on the best available data and models should be made, where possible. This estimate can then be compared with ambient conditions and known response thresholds of organisms, where available. Where solid data are too limited for reliable estimates to be made, a generalized, qualitative comparison should be made.</td></tr>
<tr><td>Characteristics of ambient conditions</td><td colspan="2">This is intended as a measure of whether the signals are likely to be detectable by marine organisms against pre-existing conditions. Marine organisms may respond to sounds or vibrations of a greater intensity or different quality than they are accustomed to. Even in noisy or turbulent environments, the operation of devices may alter the sound or vibrational environment for a considerable distance. However, in a naturally noisy and/or turbulent environment, the additional signals generated by the turbines may be masked by (undetectable against) the natural conditions. Moreover, marine organisms in the area may be accustomed to that type of an environment.</td></tr>
<tr><td>Presence of other anthropogenic signals</td><td colspan="2">Pre-existing anthropogenic activities, including other tidal developments, may already be producing similar or greater signals, which may mask or offset the risk of any additional signals produced by the proposed project. However, it is possible that the signals from each of the activities may interact to produce an even greater response in marine organisms.</td></tr>
<tr><td>Presence of species known to be sensitive</td><td>Given that a full assessment of this criterion is both labour and data intensive, focus should be placed on HCC and other species known to be particularly sensitive to this stressor (e.g. marine mammals). Several syntheses of information on impacts of tidal turbine noise on marine organisms are available (see References at the end of this Module).</td><td>Lower mobility organisms, including smaller fish, invertebrates, plankton, eggs and larvae, may be particularly vulnerable to entrainment in and disturbance by turbulence, rendering them more susceptible to predation.</td></tr>
<tr><td>Ability of organisms to evade affected area</td><td colspan="2">Noise, vibrations, and turbulence signals produced by the devices may enhance the detectability of the turbines by marine organisms and thus reduce the potential of physical encounters by organisms able to evade the structures or take another route. In fact, the use of noise-making devices (e.g. seal deterrents) may be considered as a mitigation measure to reduce the likelihood of strike or entrainment by deterring organisms (particularly marine mammals) from the site.

Please note that not all organisms may be able to leave or avoid the affected areas, especially where the signals extend well beyond the localized area (see Criterion 4).</td></tr>
</table>

5.2.4.6 - CRITERION 6: EFFECTS OF OTHER SIGNALS EMITTED BY PROJECT INFRASTRUCTURE

The intent of this criterion is to serve as a measure of the likelihood that signals emitted by the project infrastructure, other than those dealt with in Criterion 5, will adversely affect the behaviour or physiology of marine organisms.

Signals to consider include the following:

A. electromagnetic fields produced by the power cables or turbines,

B. artificial light, and

C. other emissions produced during operations, as identified by proponent or regulator.

These stressors are generally considered to present less of a risk to marine organisms than those in Criterion 5 at the present time. Moreover, there is great uncertainty regarding whether electromagnetic fields produced by power cables of the type used in tidal projects are at levels that would be detectable or of concern to marine organisms, and if so, at what distances and directions. Nevertheless, these stressors are of public concern and may be determined to present a higher risk as more experience is gained.

Responses could include the following:

- avoidance or attraction to affected areas,
- interference with navigation or orientation mechanisms/cues,
- increased stress,
- interference with communication and mate and prey detection, and
- physical or physiological damage.

Photo Credit: Greg Trowse

Table 5-9: Criterion 6 - Effects of Other Signals Emitted by Project Infrastructure

CRITERION 6 INDICATORS OF RISK		
INDICATORS	**ELECTROMAGNETIC FIELD**	**ARTIFICIAL LIGHT**
The extent of the power cabling and lights	If possible, a valid estimate of electromagnetic field output should be made based on the best available data and models. Where solid data are too limited for reliable estimates of electromagnetic field outputs to be made, a generalized, qualitative comparison should be made based on the assumption that the more extensive the cabling and higher the transmission capacity, the greater the potential intensity and spatial influence. This should also take into consideration whether the cables are shielded and/or buried. Characteristics of the transmission (e.g. Dc vs. AC) are also important.	This would only be a factor associated with surface structures.
Characteristics of ambient conditions	This is intended as a measure of whether the disturbance is likely to be detectable by marine organisms against pre-existing conditions. Marine organisms may respond to electromagnetic fields of a greater intensity or different quality than they are accustomed to. While it is possible that fields may be masked by (undetectable against) the natural conditions or that marine organisms may be accustomed to such signals, this should not be assumed.	n/a
Presence of other anthropogenic signals	Pre-existing anthropogenic activities, including other tidal developments, may already be producing similar or greater signals, which may mask or offset the risk of any additional signals produced by the proposed project. However, it is possible that the signals from each of the activities may interact to produce an even greater response in marine organisms.	
Presence of species known to be sensitive	Given that a full assessment of this criterion is both labour and data intensive, focus should be placed on HCC and other species known to be particularly sensitive to this stressor. Several syntheses of information on impacts of electromagnetic fields on marine organisms are available (see References). For example, elasmobranchs (i.e. sharks, rays, and skates) are known to be particularly sensitive to electromagnetic fields and may exhibit behavioural reactions to underwater power cables of the type associated with tidal turbines (including avoidance, attraction, and aggression towards the cables). Benthic organisms may also be particularly vulnerable to electromagnetic fields given their proximity to the source of the emissions.	Artificial lights may attract certain organisms, particularly marine birds, mammals, and turtles, which may increase risk of strikes or entrainment.
Ability of organisms to evade the affected area	Some organisms may be repelled by electromagnetic fields. This may reduce the potential of physical encounters by organisms able to evade the structures or take another route. However, not all organisms may be able to relocate or avoid the affected areas, especially those that extend across migratory pathways or if the site has extensive cabling systems (see Criterion 4).	Artificial lights may enhance the detectability of the turbines by marine organisms and thus reduce the potential for physical encounters by organisms able to evade the structures or take another route.

5.2.5 - STEP 4: IDENTIFYING RISKS OF INTERFERENCE WITH OTHER HUMAN USES

One non-scientific factor that is appropriate for inclusion as a distinct criterion in the categorization of risk level is the potential for interference with other human uses of the marine and coastal ecosystem. Examples of relevant human uses include the following:

- commercial, recreational, subsistence, and aboriginal fisheries;
- aquaculture;
- marine transportation/navigation;
- tourism and recreational uses (e.g. boating, surfing, diving, whale watching, beaches);
- subsea cabling and pipelines; and
- mining and oil and gas operations.

Some uses may be displaced or disrupted by the presence of a tidal energy development. Others may be able to coexist without significant disruption. Both current and probable future uses should be considered. However, the risk level may be weighted higher for current uses. By incorporating implications for the environment and other human uses, an integrated management approach can be taken in project planning and decision-making, including the design of mitigation and adaptive management measures. Information on the degree of risk to various uses may be available through a marine spatial planning, socioeconomic impact assessment, and/or consultations with stakeholders.

Given the purpose is to support objective planning and decision-making that prevents development projects from causing significant adverse effects on the natural environment, other socioeconomic values, such as effects on the local and regional economy, jobs, business development, and contribution to meeting renewable energy targets should not be considered within the environmental risk assessment and decision-making process. These may be considered after the project is determined to be environmentally acceptable.

5.2.6 - STEP 5: CATEGORIZING RISK

Once a project proposal is completed, reviewers (e.g. planners or regulators) would assess the available information against each criterion. Each criterion (environmental and other human uses) should be considered of equal weight. Therefore, following a precautionary approach, a high risk score in one criterion could place the entire project in the high risk level. With no high risk criteria, and even one moderate, the overall risk level of the project would be moderate. If all criteria are low risk, the project would be classified as low risk.

Each risk level is associated with an appropriate management decision on whether or not the project is suitable to proceed.

Table 5-10: Categories of Risk of a Proposed Project

CATEGORIES OF RISK OF A PROPOSED PROJECT	
RISK LEVEL	**RECOMMENDED MANAGEMENT DECISION**
Low	Project may proceed without further review.
Moderate	Project as proposed will require a more detailed review and/or environmental studies and/or monitoring program before receiving approval.
High	Project as proposed will require an in-depth review with further environmental studies and/or monitoring before receiving approval.
Extremely high	Project poses an unacceptable risk and may not proceed as proposed. Major redesign and/or relocation are required. Revised proposals will need to be re-submitted.

5.2.7 - OTHER CONSIDERATIONS

For large-scale commercial projects, where there may be a greater potential for an environmental impact, the risk can be mitigated using an adaptive, staged development approach, where the development is scaled-up, in terms of size (number of devices, production capacity), in incremental stages over time. Proposals for larger-scale projects that incorporate an incremental growth approach may qualify at a lower risk, requiring a less extensive initial review (than an equivalent project without staged growth) as long as a well-designed monitoring, re-assessment (at each stage) and adaptive management procedure is put in place.

By developing commercial-scale projects in a staged, precautionary and adaptive manner, regulators, scientists and developers will be able to gain valuable knowledge and experience on the baseline environment and the effects of the technology. Since project proponents cannot be expected to be responsible for research and monitoring beyond the scope of their project, credit should be given to projects that include a strong independently-run environmental research program. Applied research and monitoring will benefit both proponents and regulatory agencies by facilitating efficient project planning, environmental assessment, monitoring, and mitigation.

5.2.8 - STEP 6: SUPPLEMENTARY MITIGATION

Moderate and/or high risk projects face delays and added costs associated with the need for a more in-depth review, baseline studies and monitoring program, as well as the continued risk that the project could be rejected. However, the project may be downgraded to a low risk level by applying appropriate mitigation measures that address all the indicated risks (both to the environment and other human uses), thereby allowing the project to proceed without the need for further review. Mitigation may involve relocation to a site less likely to be negatively affected, change in the timing of project activities (especially for short-term projects), adjustments to the size or configuration of the development, or use of mitigation devices, such as erosion protection or fish/marine mammal deterrents. Extremely high risk proposals require major revisions and must again proceed through all the steps.

5.2.9 - STEP 7: PREPARING A MONITORING AND ADAPTIVE MANAGEMENT PROGRAM

When a project is approved, follow-up activities, including research and monitoring, are key to reducing scientific uncertainty and allow improved decisions to be made in the future. These activities should be incorporated into the conditions for approval of any project.

An iterative process of risk assessment and mitigation is required. 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 the following:

- monitoring requirements,
- timelines and/or conditions for re-assessment, and
- an adaptive response plan.

While specific adaptive management measures may not be identifiable at that point, a strategy or plan should be developed to provide context on when, how, and where adaptive management may be used. Decisions to adopt specific adaptive management measures can be identified later during the project life-cycle based on the results of the follow-up or monitoring program.

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 will ensure that appropriate and timely actions are taken to mitigate the cause of the change and minimize the potential for a significant adverse ecological effect to result. Response(s) could include the following:

- 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, reassessments would occur at a predefined interval or condition and/or as new or improved information is gained on the baseline environment or impacts. Where new risks are identified or previously predicted risks are unsubstantiated, monitoring and mitigation requirements can be adapted.

For more information on this topic, see: Operational Policy Statement: Adaptive Management Measures under the Canadian Environmental Assessment Act. http://www.ceaa-acee.gc.ca/default.asp?lang=En&n=43952694-1

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