EXECUTIVE SUMMARY

This report is a background study on ocean renewable energy which is intended to facilitate a Strategic Environmental Assessment (SEA) of potential tidal energy development projects in the Bay of Fundy. This study has been commissioned by the Offshore Energy Environmental Research Association (OEER) and co-funded by the New Brunswick Department of Energy.

Nova Scotia's current energy mix is primarily dominated by coal, which provides approximately 75% of the Province's electrical power. In Nova Scotia, Renewable Energy Standard Regulations, made under Section 5 of the *Electricity Act*, specify two main requirements. The *Renewable Energy Standard 2010* requires each load serving entity to provide customers with renewable low-impact electricity equivalent to at least 5% of its total annual sales for the calendar years 2010, 2011, and 2012. The R*enewable Energy Standard 2013* requires each load serving entity to provide its customers with renewable low impact electricity equal to at least 10% of its total annual sales. New Brunswick has a more diverse energy mix including; hydro, oil, coal, diesel, natural gas and nuclear generation. Pursuant to the *Electricity Act*, Regulation 2006-58 will require standard service suppliers to provide a minimum renewable energy component of 10% of kilowatts-hours sold by the year 2016 in the Province of New Brunswick. Price volatility of foreign energy supplies will affect both provinces, and the need to develop local energy resources will play an increasingly critical role in ensuring energy security for both the Provinces of New Brunswick and Nova Scotia.

In addition to regulated demand, there is also an increasing market demand for electricity generated by renewable sources such as tidal power, to reduce greenhouse gas (GHG) emissions and avoid the purchase of offset credits otherwise needed to meet reduction commitments. Tidal power generated in the Bay of Fundy is viewed as a potentially significant part of the renewable energy mix for Nova Scotia and New Brunswick.

Key study limitations in addition to those included in the terms of reference provided by OEER, include the following:

- The information provided in this report is at an overview level and based on readily available sources. There are information gaps in the description of existing environmental and socioeconomic conditions, ocean energy technologies, potential environmental interactions and management strategies.
- Development scenarios have been presented for illustrative purposes based on several factors including available tidal energy, and jurisdictional and ecological diversity. This report does not claim that these are "preferred" scenarios or that other locations would not be viable.
- It is assumed that all specific ocean energy projects, including demonstration projects, will be subject to project and site specific environmental assessment requirements as part of a regulatory environmental approvals process. This site specific evaluation, including consultation with potentially affected stakeholders, is considered vital for a complete evaluation of potential environmental effects and their significance as well as the development of specific mitigation and monitoring programs.
- Given the lack of specific knowledge on the nature, location and timing of potential tidal power development projects in the study area, potential interactions are described in general terms. Potential environmental issues are identified as well as an overview of general planning and

management considerations which may be implemented to avoid or reduce potential environmental interactions.

Based on the results of an issues scoping exercise, a list of Key Environmental Issues (KEIs) was prepared from which to focus this evaluation. The KEI's evaluated include: Critical Physical Processes; Fisheries; Fish and Fish Habitat; Marine Benthic Habitat and Communities; Pelagic Communities; Marine Mammals; Marine Birds; Species at Risk; Aquaculture; Marine Transportation; Tourism and Recreation; Marine and Coastal Archaeological and Heritage Resources; and Economic Development.

As requested by OEER, overview descriptions of several available marine-based energy conversion approaches are presented and discussed in the report; these include:

- Offshore Wind Energy Conversion;
- Tidal In-Stream Energy Conversion (TISEC);
- Tidal Lagoon Energy Conversion; and
- Wave Energy Conversion.

As requested by OEER, only TISEC is addressed in detail with respect to the Bay of Fundy; however, the other technologies may also be valid for certain applications subject to further evaluation and assessment.

Some aspects of a typical TISEC project construction and operation directly influence various biological and socioeconomic components, and some influence the physical processes, which could in turn influence the biological components. The following table outlines typical project components and potential physical, biological and socioeconomic interactions. The potential interactions and environmental management and planning considerations with respect to several development scenarios are outlined in more detail in this report.

TABLE E.1 Typical Environmental and Socioeconomic Interactions with TISEC Projects

Project/Construction Phase	Physical Process Interaction	Biological Component Interaction	Socioeconomic Component Interaction
Seabed Preparation	▪ Sediment transport ▪ Waves/currents through channel modification ▪ Noise and vibrations ▪ Introduction of additional hard-substrate	▪ Marine Benthic Habitat and Communities ▪ Fish and Fish Habitat ▪ Marine Mammals	▪ Marine Transportation ▪ Economic Development ▪ Marine and Coastal Archaeological and Heritage Resources ▪ Fisheries ▪ Aquaculture ▪ Tourism and Recreation
Pile Installation	▪ Sediment transport (sediment suspension and initiation of scour) ▪ Noise and vibrations	▪ Marine Benthic Habitat and Communities ▪ Fish and Fish Habitat ▪ Marine Mammals	▪ Marine Transportation ▪ Economic Development ▪ Fisheries ▪ Aquaculture ▪ Tourism and Recreation

TABLE E.1 Typical Environmental and Socioeconomic Interactions with TISEC Projects

Project/Construction Phase	Physical Process Interaction	Biological Component Interaction	Socioeconomic Component Interaction
Gravity Foundation Installation	▪ Sediment transport (sediment suspension and initiation of scour) ▪ Introduction of additional hard substrate	▪ Marine Benthic Habitat and Communities ▪ Fish and Fish Habitat ▪ Marine Mammals	▪ Marine Transportation ▪ Economic Development ▪ Fisheries ▪ Aquaculture ▪ Tourism and Recreation
Scour Protection Installation	▪ Sediment transport (sediment suspension) ▪ Introduction of additional hard-substrate (if traditional protection is used)	▪ Marine Benthic Habitat and Communities ▪ Fish and Fish Habitat	▪ Marine Transportation ▪ Economic Development ▪ Fisheries ▪ Aquaculture ▪ Tourism and Recreation
TISEC Installation	▪ Modified currents ▪ Reduction in total tidal energy	▪ Marine Benthic Habitat and Communities ▪ Fish and Fish Habitat ▪ Marine Mammals ▪ Marine Birds (especially if surface-piercing structures are involved)	▪ Marine Transportation ▪ Economic Development ▪ Fisheries ▪ Aquaculture ▪ Tourism and Recreation
Cable Installation	▪ Sediment transport (sediment suspension, exposure of fines, scour)	▪ Marine Benthic Habitat and Communities ▪ Marine Mammals (temporary displacement) ▪ Fish and Fish Habitat	▪ Marine Transportation ▪ Economic Development ▪ Fisheries ▪ Aquaculture ▪ Tourism and Recreation
Project Operation	▪ Reduced currents ▪ Modified waves ▪ Degradation of anti-fouling coatings ▪ Electro-Magnetic Fields (EMF)	▪ Marine Benthic Habitat and Communities ▪ Marine Mammals ▪ Fish and Fish Habitat	▪ Marine Transportation ▪ Economic Development ▪ Fisheries ▪ Aquaculture ▪ Tourism and Recreation
Maintenance	▪ New anti-fouling agents ▪ Spills from maintenance vessels ▪ Re-introduction of lubricating oils	▪ Removal of marine life affixed to TISEC unit ▪ Spill impacts on Marine Mammals, Marine birds, and Fish and Fish Habitat	▪ Marine Transportation ▪ Economic Development ▪ Fisheries ▪ Aquaculture ▪ Tourism and Recreation
De-commissioning	▪ Similar to construction	▪ Similar to construction	▪ Similar to construction

Reference: after Michel *et al.* 2007

Details on the specific nature and spatial and temporal distribution of potential tidal power projects in the Bay of Fundy and their environmental effects are not available at this time. For the purposes of this study it was necessary to develop several example development scenarios to further focus this evaluation.

Based on the existing environment of the region and the potential environmental interactions and issues identified, key environmental management considerations are identified in the report to help guide future planning for tidal power development projects in the Bay of Fundy.

One of the key components of this study is the identification of data gaps that make it difficult to accurately predict environmental consequences of potential interactions with project activities. The following table provides a summary of the data gaps and associated recommendations by KEI.

TABLE E.2 Summary of Data Gaps and Recommendations

Key Environmental Issue	Data Gap	Recommendation
Critical Physical Processes	▪ Lack of detailed, site specific information on vertical and horizontal current structure and substrates for validation of models. ▪ Inadequate fine-scale hydrodynamic and sediment models relevant to selected sites of tidal energy development. ▪ Limited knowledge of the overall distribution and dynamics of sediments in the Bay of Fundy. ▪ Limited application of hydrodynamic models to assess the impacts of TISEC developments.	▪ Gather site specific information about substrates and sediment movement and currents for proposed development locations using in situ monitoring with ADCP and sediment sensors. ▪ Complete high density multibeam bathymetric studies of the Bay, and complete the analysis of existing data. ▪ Adapt or refine hydrodynamic models to provide adequate small-scale analyses of the potential and effects of energy extraction developments. ▪ Hydrodynamic modeling should be used to assist with the selection of sites for TISEC developments in order to optimize the extractable tidal energy potential and minimize cumulative effects on physical or biological processes.
Fisheries	▪ Absence of information on fish behaviour with respect to TISEC technologies. ▪ Inadequate knowledge on the effects of remobilized sediments on commercially important species of fish and shellfish. ▪ Questions about EMF from sub-sea cables and the effects on demersal fish and shellfish. ▪ More specific information is required regarding the number of fishing operations, vessels and products, and locations of fixed gear fisheries. Present data gathered for fisheries management purposes is insufficient for assessment of tidal power implications. ▪ Assumed existing infrastructure such as wharves would be used to support TISEC development projects—infrastructure status and availability or requirements for tidal power development is not well known. ▪ Lack of clarity on set-back requirements for marine energy developments.	▪ Conduct experimental and field-based monitoring studies of fish behavior and mortality, in the vicinity of tidal power devices. ▪ Conduct experimental studies of fish responses to vibrations or noise generated by TISEC devices. ▪ Conduct experimental studies of effects of high suspended sediments on migratory and commercial fish species. ▪ Work with fishing groups to obtain better fisheries data particularly with respect to activities near proposed development sites. ▪ Determine specific infrastructure requirements (e.g., wharves, supply bases) and necessary upgrades for each proposed project. ▪ Gather detailed information on potential adverse effects on local fisheries, and necessary mitigative measures (including project site selection). ▪ Establish consultative group including fishers and developers to create effective set-back guidelines.
Fish and Fish Habitat	▪ Data on distribution, seasonality and trophic relations of many non-commercial species of fish are not available. ▪ Absence of information on fish	▪ Conduct experimental and field-based monitoring studies of fish behavior and mortality, in the vicinity of tidal power devices. ▪ Conduct experimental studies of fish

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	behaviour and/or mortality with respect to TISEC technologies, particularly with respect to noise and vibration. ▪ Questions about EMF from sub-sea cables and the effects on demersal fish.	responses to vibrations or noise generated by TISEC devices ▪ Establish an ongoing and updatable database of knowledge about local and migratory fish stocks. ▪ Identify potential mitigative measures for effects on fish populations based on experimental results.
Marine Habitat and Benthic Communities	▪ Available data on existing benthic communities are limited in the Outer Bay. ▪ Available data on existing benthic communities of the Upper Bay are limited, especially in view of some significant changes that have happened in the Bay since the data were obtained. ▪ Little existing data for many areas in the Bay.	▪ Replication of broad benthic surveys that were conducted in the 1970's. ▪ Establishment of long-term survey transects of benthic habitats and communities in priority areas for energy developments, including reference (*i.e.* non-impacted) sites. ▪ Creation of a coordinating agency to ensure consistency and quality of monitoring activities.
Pelagic Communities	▪ Similar to Fisheries and Fish and Fish Habitat issues noted above with respect to pelagic species.	▪ Similar to Fisheries and Fish and Fish Habitat issues noted above with respect to pelagic species.
Marine Mammals	▪ Lack of data on marine mammal behavioural responses to TISEC devices. ▪ Limited data available on the occurrence of marine mammals in the Upper Bay of Fundy.	▪ Study long term effects of health and behavior (*e.g.*, mortality, migration, avoidance, attraction) of tidal power development on marine mammals including monitoring of results from pilot and demonstration projects in the Bay of Fundy and elsewhere. ▪ Establish long term monitoring programs for marine mammals in the Upper Bay of Fundy, incorporating NGO resources. ▪ Identify and assess possible mitigative measures for effects of TISEC development on mammals.
Marine Birds	▪ Lack of data on marine seabird and shorebird activity in the area of priority sites. ▪ Lack of information on the trophic relationships of many marine birds, and their ability to adjust feeding preferences.	▪ Establish long term monitoring programs for marine birds in the Upper Bay of Fundy, incorporating NGO resources. ▪ Surveys to support project-specific environmental assessment prior to deployment. ▪ Identify and assess possible mitigative measures for effects of TISEC development on birds, including the secondary effects associated with changes in prey availability.

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Key Environmental Issue	Data Gap	Recommendation
Species At Risk	▪ Requirement for better site -specific information on species presence (depending on species and location).	▪ Establish an ongoing and updatable database of knowledge about local and migratory species at risk in the Bay of Fundy. ▪ Identify and assess potential mitigative measures for different species at risk. ▪ Work with Species Recovery Teams to develop comprehensive strategies for species at risk that use areas of high priority for energy extraction. ▪ Where necessary, conduct species-specific surveys in high priority areas.
Aquaculture	▪ Similar to Fisheries above (including lack of knowledge concerning appropriate setback distance from TISEC devices).	▪ Similar to Fisheries above.
Marine Transportation	▪ Uncertainty regarding level of interaction with other marine transportation users in the study area.	▪ Stakeholder consultation (other marine users). ▪ Regulatory consultation (*e.g.*, *NWPA* process). ▪ Detailed navigation safety assessments and underkeel clearance surveys in the context of site specific project EA and project site selection.
Tourism and Recreation	▪ Lack of information on informal and unregulated recreational activities.	▪ Project-specific data gathering as part of site specific EA process (including shore-based facilities).
Marine and Coastal Archaeological and Heritage Resources	▪ Uncertainty regarding the location and condition of many potential archeological and heritage resources (marine and shore-based) in the study area.	▪ Detailed site specific bathymetric survey using side-scan sonar as part of project specific EA process. Follow up with ROV survey if sonar shows potential resources. ▪ Detailed archeological survey may be necessary as part of shore-based facility site selection and EA process.
Economic Development	▪ Uncertainty in identification of specific business opportunities for local business. ▪ Local capacity not clear.	▪ Local economic benefits study in context of project specific EA process. ▪ It is recommended that an Energy Sector Capability Study be commissioned for Atlantic Canada to address the barrier to supply-chain deficiencies within Atlantic Canada's Energy Sector, particularly within Nova Scotia and New Brunswick. ▪ Study potential benefit agreements. ▪ Project-specific job fairs.

TISEC technology is in a very early stage of development. Many potentially applicable devices are barely beyond the prototype stage, and few have been tested for prolonged periods in the marine

environment. While the technology is developing rapidly in the case of the few that have been field tested, they all lack adequate examination for their potential environmental effects. Even where field testing has included some degree of environmental effects monitoring, it is not possible to transfer the limited information so far available on the environmental effects from those test sites to the Bay of Fundy. It is therefore necessary to establish facilities at one or more sites in the Bay of Fundy at which such technologies can be tested and thoroughly monitored; it is acknowledged that planning for the first of such facilities is currently under way.

It is recommended that a cautionary, staged approach be taken with respect to development of TISEC technology projects in the Bay of Fundy. Many unknowns exist and it is the recommendation of this study team that a small number of pilot scale projects proceed with significant monitoring and adaptive management plans. This would allow for future expansion into demonstration and commercial scale developments, provided environmental and socioeconomic components in the Bay of Fundy are not compromised, to the satisfaction of government and local stakeholders. This would be accomplished by gathering data to address the data gaps and allow for design considerations and development of appropriate mitigation measures. The end result would be confident predictions of potential environmental effects through project-specific environmental impact assessment.