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Tidal Energy:
Strategic Environmental Assessment (SEA) Update for the Bay of Fundy





Environment

Offshore Energy Research Association of Nova Scotia

Tidal Energy: Strategic Environmental Assessment Update for the Bay of Fundy

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January, 2014

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January 21, 2014

Jennifer Pinks, M.Sc.
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Dear Ms. Pinks,

Project No: **60290436**

Regarding: **FINAL REPORT Tidal Energy: Strategic Environmental Assessment Update for the Bay of Fundy, Nova Scotia**

AECOM Canada Ltd. and the Acadia Tidal Energy Institute are pleased to submit the enclosed final version of the report entitled *Tidal Energy Strategic Environmental Assessment Update for the Bay of Fundy, Nova Scotia*.

This report incorporates comments to earlier drafts made by members of the Stakeholder Roundtable and OERA's Technical Review Committee. It summarizes the Province's renewable energy goals and objectives and presents background information regarding the tidal energy industry in the Bay of Fundy. Our project team has focused on changes to the industry since 2008 and research/monitoring work undertaken over the past five years. We have also summarized the issues and concerns raised at public forums and outlined approaches to address these issues.

We greatly enjoyed working with OERA on this important project. The renewable electricity generated by tidal energy projects will benefit all Nova Scotians for many years to come. Thank you again for inviting us to contribute to this innovative and technically challenging industry.

Sincerely,
AECOM Canada Ltd.

Russell Dmytriw, P.Geo.
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Executive Summary

In 2007 the Nova Scotia Department of Energy commissioned the Offshore Energy Research Association of Nova Scotia (OERA) to complete a Phase I Strategic Environmental Assessment (SEA) to guide the development of tidal energy in the Bay of Fundy. Since that time, the tidal energy industry has evolved in Nova Scotia; consequently OERA commissioned this Phase II SEA Update to accomplish two primary objectives:

1. Describe the contemporary state of the tidal energy industry both regionally and globally; and,
2. Present the current scientific and community knowledge base on this subject in the Bay of Fundy.

Many of the 29 recommendations in the 2008 SEA have been fully implemented or are currently being addressed; only three recommendations remain outstanding. Considerable environmental and biophysical research, targeting priorities identified in 2008 and since that time, has been completed or is currently underway. Modifications to environmental and electricity regulations have been made to further encourage the development of a made-in-Nova Scotia tidal energy industry.

Since 2008, two fundamental changes have occurred in the tidal energy industry that will affect projects developed in Nova Scotia. First, proponents of the most advanced technologies are now seeking sites that can host arrays of turbines for commercial purposes, rather than individual sites for demonstration of their technologies. Second, the industry has evolved large devices to serve utility-scale *transmission* projects, as well as smaller units suited to community-scale *distribution* projects. The provincial Department of Energy has supported this development through the introduction of the Developmental FIT and COMFIT programs, which offer power producers fixed prices for the electricity produced. These different project types and supporting regulatory incentives offer a number of opportunities for the Nova Scotia marine industry and the skilled services and technologies that support this industry.

Tidal energy is expected to help lessen the Province's dependency on imported fossil fuels and reduce greenhouse gas and air pollutant emissions. Current provincial legislation requires 25% of the electricity consumed in Nova Scotia to be generated from renewable sources by 2015. By 2020, this target rises to 40%. Both of these targets appear achievable under the renewable energy planning and development scenarios currently in place. The economic benefits that can be realized by participating in the emerging tidal industry combined with the increased energy security that it can bring to the Province, account for the Province's continuing commitment to tidal energy.

Since 2008, monitoring and site investigations near the FORCE site in Minas Passage and elsewhere in Minas Channel have provided a much more complete understanding of critical subject areas that were not well known in 2008. These advances include:

Energy Resource Assessment: Numerical modeling of tidal flows in Minas Passage has been carried out by several research groups. Their models investigate the effects of increasing the number of tidal turbines in Minas Passage. Results indicate that the total energy in the Passage exceeds 7 GW, of which about 1.4 GW is potentially extractable with only a small impact upon tidal range at the head of the Bay of Fundy.

Sediments and Substrate: Researchers have used several approaches to model potential changes in sediment movement and deposition that may result from extracting energy from the water column.

Submerged Ice: The risk that sediment-laden submerged ice may collide with tidal energy devices has been evaluated in several studies. By examining sediment-laden ice characteristics and its formation along the shoreline of Minas Basin, it appears that ice blocks would not be dense enough to be a hazard to turbines.

Ambient Noise: Three studies have been completed to measure ambient noise levels at the FORCE site. The results indicate that the noise from an operating turbine should be distinguishable from the ambient noise using a pair of hydrophones installed on a modified high flow mooring. The technology is rapidly advancing and it seems promising that it will soon be possible to monitor ambient noise better and to distinguish certain mammal vocalizations from the background noise.

Marine Mammal Monitoring: A collaborative project between Acadia University and the Sea Mammal Research Unit Ltd. employed two types of passive acoustic monitoring sensors in Minas Passage to monitor the presence of harbour porpoise and white-sided dolphins. Results confirmed the near year-round presence of porpoises, with peak activities appearing to be associated with the migration of herring and other fish. Future deployments of hydrophones and active acoustic instruments could provide sufficient insight into turbine-mammal interactions to enable an effective assessment of the risk posed to marine mammals.

Fish Tracking: A comprehensive fish tagging study (an Acadia led project in collaboration with the Ocean Tracking Network and Fisheries and Oceans Canada) was undertaken to understand where within the water column selected species swim as they transit Minas Passage. The study tagged striped bass, American eel, Atlantic salmon and Atlantic sturgeon to monitor their temporal and spatial trends within Minas Passage, their movement direction and swimming depth. Results indicate that individual striped bass may undertake multiple crossings over short periods of time and may swim at depths and locations in the Passage that coincide with probable depths and locations of TISEC devices. Sturgeon were found to occupy much of the water column, rather than merely the near-bottom region as previously thought.

Monitoring Technologies: In order to address the need for continuous and reliable environmental monitoring in high current environments, FORCE is leading a consortium of interests to develop a durable sea bottom sensor platform that could be deployed for long periods of time. Entitled the Fundy Applied Sensor Technology (FAST) Project, the objective is to develop a recoverable cabled platform to which a variety of sensors could be attached.

Mi’kmaq Ecological Knowledge Studies: Two Mi’kmaq Ecological Knowledge Studies, together covering the entire Bay of Fundy, have been completed to assess the potential impacts to the Mi’kmaw people by examining their land and resource use practices and traditional knowledge base.

Southwest Nova Tidal Resource Characterization: A tidal resource assessment was conducted as a collaborative effort between Dalhousie University, Acadia University, Nova Scotia Community College and Fundy Tidal Inc. to identify sites in the area that may be suitable for tidal energy generation. There are three sites in the Digby area with sufficient tidal resources to support small scale commercial arrays. Preliminary results also suggest that other areas of coastal southwest Nova Scotia may also host tidal currents of sufficient velocity for tidal power development.

Despite these advances, a number of subject areas require additional study to improve our understanding of the environmental effects of tidal energy on biophysical systems and the existing socio-economic environment. On-going government supported research is addressing critical priorities in the Bay of Fundy. Academic institutions and provincial agencies have established strategic partnerships and information sharing agreements with their international counterparts to maximize research efficiency and benefit from new developments elsewhere. At this time, functional, in-water tidal energy devices are needed to allow researchers to assess the risk that these installations may pose to marine biota.

To a certain degree, questions, issues and concerns expressed during the course of this update reflect those reported in the 2008 SEA. However, three items of particular interest were noted:

1. Both community residents and the Mi'kmaw Conservation Group expressed concern over the lack of potential, clearly documented tidal energy "showstoppers" – that is, a definition or list of anticipated or unanticipated environmental effects that would, individually or in combination, result in the removal of tidal energy turbines. The MCG suggests that the government and tidal developers together develop a plan that clearly expresses how, and under what conditions the turbines would be removed.

2. Both residents and the Mi'kmaw Conservation Group requested additional clarity regarding opportunities for future economic development resulting from this industry. Although both groups recognize the difficulty in defining specific economic benefits at this early stage, both felt that on-going opportunities to meet and participate in discussions as the industry developed would provide useful information to help them make informed decisions on the subject.

3. Community residents support the Province's incremental approach to tidal energy development and recognize the benefits from assessing potential impacts and benefits in a step-by-step fashion. Despite this, several residents in different forums commented on the apparent slow pace of development, compared to their expectations in 2008. It was generally understood by forum participants that the Bay of Fundy is a significantly more challenging working environment than perhaps was originally appreciated. At the same time, the pool of international venture capital needed to commercialize this emerging investment is limited.

Tidal energy projects share the seabed and water column with other marine users. To the extent that these uses overlap in space or time, a strategic and consultative process, backed by reliable information on marine space use by different groups, is required to resolve conflicts that may develop. Integrated Coastal Management Planning and/or Marine Spatial Planning have been used elsewhere in the world (and in Nova Scotia) to identify potential overlapping interests, establish priorities for use and protection, and outline processes to resolve future conflicts. Integrated Coastal Management Planning is recommended as a future step that will contribute to the development of Nova Scotia's tidal energy industry.

The tables below summarize the current key environmental and socio-economic topics associated with tidal energy development in the Bay of Fundy and provide approaches to address these issues. The recommendations are classified as "Category A" to indicate priority over the near term (to five years from now) and "Category B" to indicate priority over the longer term. The final table includes recommendations made at the conclusion of the 2008 SEA that have been partially addressed or not addressed to date. The full list describing the current status of all 29 recommendations from 2008 is presented in Appendix A.

Table A. Environmental Topics of Interest

Biophysical Topics	Observations & Recommendations
A. Tidal Lagoons. The ecological implications of tidal lagoon projects in Nova Scotia have not been extensively explored because at present there has been no formal registration of a well-defined project.	Observation: Additional specific and detailed information describing a Nova Scotia tidal range project would be needed so that targeted baseline and environmental effects research could be undertaken. Past studies of tidal range-based proposals and of existing tidal barriers (e.g. causeways) provide a wealth of basic knowledge that could be applied if a detailed, formal proposal for a tidal lagoon in Nova Scotia were to be made. Major environmental issues for consideration include: effects on hydrodynamics; effects on mammals, fish and fisheries; and sedimentation – both near-field and far-field.
B. Need for Operating TISECS. The major risks of in-stream and tidal range developments are associated with changes in hydrodynamics (flow velocity, turbulence etc.), electromagnetic effects, and the direct and indirect effects on marine fish, mammals, birds and turtles. Quantification of these risks is not yet possible because of the few deployments, limited monitoring, and technology-specific features of the tidal devices tested.	Observation: The adaptive management approach recognized by the NSDOE, DFO, and the US Federal Energy Regulatory Commission (FERC) is reportedly an effective method of managing the risks posed by these developments. Observation: Nova Scotia researchers are currently monitoring research on the environmental effects of TISEC devices deployed in other countries. Important knowledge can be gained from other jurisdictions, in particular through agreements with the United Kingdom. The lack of direct experience with extended TISEC deployments anywhere in the world, and the site-specific nature of environmental effects, underline the importance of continued evaluation of the impacts to marine resources (especially species at risk) and the value of information exchange with groups involved in TISEC research outside Canada.
C. Energy Extraction. The potential effects of energy extraction on physical processes (tidal currents, vertical mixing, sediment dynamics) constitute a key environmental issue. Empirical data on tides in the Bay of Fundy are extremely limited. Tidal data is important both for more accurate resource assessment and for modelling environmental effects. Larger soft-bodied forms such as jellyfish and comb-jellies might be particularly susceptible to the shear forces and turbulence associated with TISEC devices. If large scale energy extraction results in increases in tidal range – and hence tidal mixing – in the Outer Bay of Fundy, increased availability of deeper-dwelling pelagic species to mammal, fish and bird predators could be a significant outcome.	1. **Recommendation C1 (Category A):** The Province and academic institutions should continue to fund and undertake research into resource assessments and hydrodynamic and sediment modeling to further refine our understanding of the effects of energy extraction. Observation: Past research and modeling indicates that an increase in vertical mixing in the Outer Bay may result in increased biological productivity, with possible positive effects on, for example, some fisheries. 2. **Recommendation C2 (Category B):** Far field effects monitoring by proponents and researchers of larger (e.g. FIT) installations must include consideration of the critical ecological role played by soft-bodied forms such as jellyfish and comb-jellies. 3. **Recommendation C3 (Category A):** The Province should consider funding

Biophysical Topics	Observations & Recommendations
	the collection of long term tidal data at the future COMFIT tidal energy sites along Digby Neck similar to those data collected at the FORCE site.
D. Turbulence. The turbulence regime is a major uncertainty at all potential TISEC sites.	1. **Recommendation D1 (Category B):** Academic research on the subject of turbulence should continue so that potential far field and cumulative effects can be more accurately modeled as more and more turbines are deployed.
E. Fisheries. Because of widespread fishing throughout the Bay, the importance of fisheries to regional and local economies, and the fact that a number of species migrate into the Bay from many parts of the Atlantic Ocean, fisheries are an important consideration for sustainable marine energy development. Any assessment of risk to fisheries undertaken for specific projects will need to take into consideration the varied fishing activities found in different portions of the Bay. Management decisions have to be made recognizing the potential implications for a wide range of interested parties: those directly involved in fisheries and aquaculture operations, those who depend upon the same infrastructure resources, and their communities of interest.	1. **Recommendation E1 (Category A):** In order to reach valid conclusions regarding the species and habitat types in areas of future tidal energy interest, additional academic research focused on those aspects of fish and fish habitat most likely to be disrupted by both FIT and COMFIT projects is required. This work should be tailored to the environments and species of this region, including species at risk and evolve over the longer terms as arrays are deployed. A joint strategy developed by the Province and academic researchers should be considered to fund and acquire this information. 2. **Recommendation E2 (Category A):** More detailed, site-specific information regarding catches (location, tonnage, season, etc.) would be extremely useful to help determine the magnitude of impacts from displacement and exclusion so these impacts can be mitigated and potentially compensated. The Province in discussions with fishers' associations, DFO and other groups should develop and implement an information sharing system that will allow an accurate understanding of fishing pressure at potential FIT and COMFIT tidal energy sites.
F. Fish Behaviour. International studies on impacts to fish and biological habitat from tidal energy projects are not definitive and cannot necessarily be used to guide tidal energy development in the Bay of Fundy At all sites being considered for TISEC development, it is critical to obtain more detailed information about exactly where and when different species occupy or transit through the site. The limited international studies in which fish movements near TISECs have been monitored have not yet provided evidence of mortality, but equally, have not provided evidence that fish can avoid entrainment in the devices. Technology limitations are partly responsible for this.	1. **Recommendation F1 (Category A):** Academic and proponent-funded research needs to continue in Nova Scotia to assess the real risk of TISEC to fish species. The tagging program currently under way in Minas Passage (please see section 5.2.7) should be continued to provide more complete information regarding striped bass, Atlantic sturgeon, and American eel. Research regarding fish behavior near TISECs should be extended to COMFIT sites. Because of the limited capacity of academic institutions to obtain external funding for such research, government and private sector initiatives are required to facilitate and fund these research activities. 2. **Recommendation F2 (Category B):** Any development of a tidal lagoon will require the proponent to evaluate the extent of fish use of the proposed development site, which currently is entirely lacking.
G. Fish Habitat. Fish habitat is inadequately characterized in the proposed TISEC sites along Digby Neck.	1. **Recommendation G1 (Category A):** An assessment of fish habitat type and productivity should be undertaken by the proponent prior to TISEC deployment at COMFIT sites.

Biophysical Topics	Observations & Recommendations
H. Marine Benthos. The marine benthos is inadequately known in the Outer Bay.	1. **<u>Recommendation H1 (Category B):</u>** Video and/or diver observations should be incorporated in future studies undertaken by COMFIT proponents. Bathymetric surveys of the areas adjacent to future TISEC deployment sites are recommended.
I. Marine Mammals. For both tidal stream and tidal range technologies, environmental issues impacting marine mammals relate to direct effects, such as mortality associated with contact, and indirect effects, such as mortality effects on prey, changes in food concentrations as a result of changes in upwelling, and disturbance effects of construction and operation. Because of the novelty of TISEC devices, there is little information available to assess these implications. Studies in Strangford Lough (Northern Ireland) have shown that the local marine mammals avoid involvement with the MCT turbine. However, regulations require the device to be shut down if mammals approach too closely, so it is not clear that the mammals would never become involved with an active turbine. Differences between device design and operation, and site conditions limit the transferability of results from the limited monitoring of mammals at TISEC sites so far conducted. Some of the TISEC deployment strategies that have been proposed involve tethering to one or more anchor points by cables that may be essentially undetectable to marine mammals.	<u>Observation:</u> Marine mammal behavioral responses to TISEC devices in the Bay of Fundy cannot be determined until TISEC technologies are deployed. Because the Strangford Lough study was not aimed at studying behavior, it is not really feasible to infer from that study that mammals will always be able to avoid any TISEC design. Consequently, careful monitoring of mammal presence and behavior is essential for any TISEC deployment. 1. **<u>Recommendation I1 (Category B):</u>** Proponent funded observer-based monitoring should be employed at FIT and COMFIT sites until more automated technologies are available that will also give information on marine mammal movements when the animals are submersed, and hopefully provide information on the behavioral responses of mammals to the presence of operating devices. The Province through OERA should continue to fund the use of C-POD and icListen hydrophones to monitor porpoises and dolphins. If possible, mammal monitoring be expanded to areas of tidal energy interest that are not currently being monitored. <u>Observation:</u> Considerable additional study is required to assess whether technologies that are tethered by anchor cables (if such technologies are proposed in the Bay of Fundy) can be avoided by marine mammals. Exploration of potential options for deterrence should be undertaken before such turbines are installed.
J. Marine Birds. The risks posed to marine birds vary based on their ecology, the characteristics of the tidal power development, and the site location. Noise and vibrations associated with construction activities will act as a deterrent to all species of birds.	<u>Observation</u>: Shore- or vessel-based monitoring of marine bird activity in the potential TISEC sites along Digby Neck would be a valuable addition to knowledge about Bay of Fundy marine birds.
K. Area Use Conflicts. Surface-penetrating or floating structures could represent a permanent restriction for vessel activity. For safety, site preparation and construction phases will require exclusion of all other vessels (fishing, recreational and commercial) from a zone surrounding the site that is large enough to ensure minimum risk to vessels and operators. During TISEC operation, fishing activities may have to be curtailed in an area sufficient to ensure safety of fishers and to minimize the potential for fishing	<u>Observation</u>: Marine energy projects will need to be carefully evaluated for their impact on fishing, tourism and recreational activities. Some disruptive activities, such as those during construction (etc.) might be carried out at times when their impact on fishing, tourism and recreation would be much less. <u>Observation</u>: Negotiations regarding temporary and permanent access limitations must be held between project proponents and other area users. Project proponents should anticipate early and on-going consultation throughout the project preparation phase so that conflicting interests can be

Biophysical Topics	Observations & Recommendations
gear (etc.) to foul the turbine(s). Where a lagoon is to be constructed, the headpond area behind the lagoon wall is expected to be removed from access by other commercial and fishing vessels Construction and site preparation for both TISEC and lagoon developments will have similar effects on marine-based tourism activities as on fishing and transportation activities.	identified and competing claims resolved prior to deployment. Observation: MRE projects within or in close proximity to ecologically or culturally significant sites must be evaluated on a case by case basis. 1. **Recommendation K1 (Category B):** The Province needs to implement coastal zone planning techniques to address on-going area use concerns and to address the 2008 SEA recommendations (Recommendations 18-20, 25 and 26). Coastal zone planning or marine spatial planning will help identify potential area use conflicts and may lead to strategies to mitigate the effects of overlapping interests.
L. Noise and EMF. Limited knowledge exists of the effects of noise and EMF from the installation and operation of devices/arrays on marine mammals and fish including increased risk of barrier effects, habitat exclusion and species displacement.	1. **Recommendation L1 (Category A):** Proponent funded monitoring and in some cases modeling at both FIT and COMFIT sites should be used to determine: • Ambient (background) noise levels prior to deployment; • Noise levels generated from operational tidal devices; • Effects of noise on sensitive receptors such as marine mammals and fish; • Whether noise levels are causing barriers to movement for certain species along migratory routes and transit pathways; and, • Whether noise from devices is leading to habitat exclusion or species displacement. Observation: Data can be collected from monitoring/research programs of offshore wind developments (UK and Europe) to establish: • Noise levels generated during pile driving; • Effectiveness of mitigation measures to reduce noise levels; • Effect of noise from piling on sensitive receptors (e.g. marine mammals and fish); • Whether noise from piling activities associated with large wind farms is creating barriers to movement of certain species (would need links to species abundance and distribution surveys); and, • Effects of EMF on fish.
M. Cumulative Effects. There have yet to be any published models or practical research on the cumulative and synergistic impacts of large-scale TISEC arrays in conjunction with other nearby offshore industries. No TISEC projects have been installed in close proximity to one another, although the FORCE site may eventually provide some data on multiple technology installations. The presence of a single device is unlikely to have a significant effect on the environment, but the cumulative interaction of industrial farms or arrays may	1. **Recommendation M1 (Category B):** The ultimate effects of energy extraction can be predicted through hydrodynamic modeling. To improve the accuracy of these models, the Province should consider funding additional and detailed current flow measurements over the entire water column. These data are usually not gathered until specific sites are chosen for a project. The predictive ability and accuracy of the computer models will then need to be verified by observations and measurements made once a project is operational.

Biophysical Topics	Observations & Recommendations
significantly impact an area.	Observation: As projects move to array deployments in the UK, Nova Scotia-based researchers and regulators should maintain contact with their UK counterparts to transfer knowledge and experience in modeling, measuring and assessing cumulative effects.

Table B. Socio-Economic Topics of Interest

Socio-Economic Topics	Recommendation / Observation
N. Heritage Resources. Installation and maintenance of land-based infrastructure, harbour or wharf expansion, infilling, etc. could potentially destroy concealed heritage sites or artifacts. Installation and operation of submarine TISECs and cables could similarly affect submerged heritage resources, including shipwrecks.	Observation: In the absence of existing information on near-shore locations of the Bay of Fundy, surveys using bathymetric and LiDAR survey techniques should be used by the proponent to investigate sites that are considered for tidal power development.
O. Project Red Lines. At this time what would constitute an "unacceptable" level of impact to critical biophysical processes and organisms that would justify cancellation or modification of a tidal energy project for any given site or project is unclear because of significant site and technology variations.	1. **Recommendation O1 (Category A):** The Province, in consultation with regulators, developers, researchers, the Mi'kmaq and other interested parties should convene an experts' workshop whose purpose would be to try and define or quantify what levels of impact by TISEC development would be unacceptable. The participants would for example compile an inventory of the various receptors and the level or degree of impact that could result in the adaptation of TISEC projects, removal of installed TISECs or halt the deployment of further TISECs at both FIT and COMFIT sites.
P. Mi'kmaq Concerns. There is potential for disproportionate impact to Mi'kmaq communities due to their reliance on natural resources for cultural, spiritual and food harvesting purposes. There is a perceived lack of long-term engagement with the Mi'kmaq by government on issues related to resource development and resource extraction. Community members indicated that community consultation and engagement needs to be a longer term, on-going process. Because of the technical complexity of reports (such as the SEA), understanding of issues by Mi'kmaq and the general public may be limited. There is a need to take time to assist Mi'kmaw people by developing a meaningful engagement process.	Observation: Project developers and regulators should consider the potential for disproportionate impact when assessing project specific and cumulative environmental effects of tidal energy projects. 1. **Recommendation P1 (Category B):** I n advance of new tidal energy projects or significant changes to existing projects, the Province should lead a dedicated Mi'kmaq engagement process. 2. **Recommendation P2 (Category A):** To the extent practical, governments tasked with engaging Mi'kmaq communities should work with the Mi'kmaq, including KMK and the Unama'ki Institute of Natural Resources to assist the development of more effective information and education programs targeted for the needs of Mi'kmaw people.
Q. Economic Growth and Investment. There is widespread interest from	Observation: Several initiatives have been completed or are underway (e.g.,

Socio-Economic Topics	Recommendation / Observation
Mi'kmaq and Bay of Fundy communities in learning about opportunities for investment in and economic growth from tidal energy development	Drake 2012; Howell and Drake 2012; ATEI 2013; the Tidal Value Proposition Project) that can assist interested communities to determine how best they can benefit from tidal energy development. Observation: There is an opportunity to recruit Mi'kmaq people, fishers and other local residents to participate both in monitoring activities and research.
R. Energy Export Strategy. There is among some people an enduring interest in developing an energy export strategy that will outline how Nova Scotia energy consumers could benefit from the export of tidal energy from the province.	1. **Recommendation R1 (Category B)**: Energy export may occur at some point in the future following the development of large scale turbine arrays or tidal lagoon(s). In the future, the Province should consider developing an energy export strategy to assess and describe how Nova Scotians may benefit from the export of tidal-derived electricity from the province.
S. Infrastructure Upgrades. At present, an inherent limitation exists to the development of tidal energy in some locations because of inadequate infrastructure (e.g. transmission lines). This would eliminate some tidal power options unless the cost of upgrading infrastructure could be shared with other developments. There are likely to be cost implications to the actions taken to integrate tidal power into the grid.	Observation: If public funds are used to develop tidal energy projects, the Province should undertake additional analysis at COMFIT sites to understand infrastructure costs, system stability and interconnection options to neighboring regions. If private funds are used to develop these projects, then infrastructure costs would be borne by the proponent.

Table C. Outstanding Recommendations from the 2008 SEA for the Bay of Fundy

Topic	Recommendation / Observation
Outstanding Recommendations from the 2008 SEA (please see Appendix A for all 29 recommendations from 2008)	
Recommendation 6: Provincial Standard for Ecological Data The Province of Nova Scotia require all marine renewable energy proponents and their consultants to ensure that ecological data is geo-referenced and metadata compiled in accordance with the relevant provincial standard.	PARTIALLY ADDRESSED AND ON-GOING. No provincial data standards have been issued to date. A provincial government strategy is currently being developed for all spatial data, including data for renewable energy projects. FORCE berth holders are required to share non-proprietary information related to their projects with the public. FERN is consolidating a searchable information database regarding tidal energy in Minas Passage. This recommendation remains valid.
Recommendation 18: Fisheries Database The Province of Nova Scotia (a) assist DFO to develop and maintain a geo-referenced database of fisheries resources and activities to be used to determine where tidal energy development would have least impact on the fishery and other marine resource uses, and (b) develop a detailed study of potential tidal energy exclusion zone requirements by type of activity (including different types of gear use), potential impacts and possible mitigative strategies.	PARTIALLY ADDRESSED AND ON-GOING. Through OERA's Participation Support Fund in 2008, the Scotia Fundy Mobile Gear Fishermen's Association conducted a database search to document the fleet's activities and catches in the Bay, and carried out in-depth interviews with fishers to collect relevant traditional knowledge. DFO and NSE are working together on a Statement of Best Practices. DFO is currently reprocessing fish landing data to generate maps that will help show where different species are caught within the Bay. This recommendation remains valid.
Recommendation 19: Compensation and Liability The Province of Nova Scotia facilitate the development of a preliminary mitigation process to address compensation for fisheries displacement, damage to gear, and other environmental impacts, and limits to liability before any demonstration project proceeds.	PARTIALLY ADDRESSED. Although no formal mitigation/compensation process has been established by the Province, FORCE carries liability insurance which extends to all berth holders. In addition, environmental impacts are monitored (to the extent possible) on an on-going basis, and all berth holders are required to table decommissioning and restoration plans intended to return their sites to a natural state as possible. This recommendation remains valid.
Recommendation 21: Fisheries Consultation and Involvement Protocol The Province of Nova Scotia work with marine renewable energy proponents, local fishers and other fisheries interests to develop procedures and protocols to ensure that fishers and fisheries stakeholders are informed and consulted at every stage of tidal development, both by the Province and by proponents.	PARTIALLY ADDRESSED AND ONGOING. Although no formal procedures or protocols have been developed, the Province through OERA has participated in the engagement component of the updated SEA and other past tidal-related initiatives. FORCE has continued to include local fishers and Mi'kmaq representatives on EMAC, and supported a collaborative project between local weir fishers and researchers at Acadia University. This recommendation remains valid.
Recommendation 25: Integrated Coastal Zone Management The Province of Nova Scotia develop an Integrated Coastal Zone Management (ICZM) Policy for the Bay of Fundy before large scale commercial marine renewable energy developments are allowed to proceed.	NOT ADDRESSED. The Province currently uses the Coastal Management Framework to manage coastal areas and issued a Draft Coastal Strategy for public comment in 2011. Public comments were summarized and presented to the Province in 2012. Should commercial arrays be proposed,

Topic	Recommendation / Observation
	more focused ICZM planning may help to minimize overlapping claims and mitigate conflict. This recommendation remains valid.
Recommendation 26: Geo-Referenced Tools to Indicate Opportunities and Constraints Nova Scotia, New Brunswick and Canada collaborate to prepare and maintain geo-referenced tools to indicate opportunities and constraints for the full range of marine renewable energy technologies, to support the allocation of marine renewable resources within the context of an Integrated Coastal Zone Management Policy.	NOT ADDRESSED. This recommendation remains valid although New Brunswick has chosen not to development marine renewable energy in the Bay of Fundy at this time.
Recommendation 28: Public Education and Awareness The Province of Nova Scotia work with marine renewable energy proponents, research institutions and environmental and community organizations involved in sustainability education, to develop a strategy for public education and awareness about marine renewable energy technologies.	PARTIALLY ADDRESSED AND ONGONG. Since 2008 the Province has collaborated with research groups and industry to promote tidal energy development and have liaised (through OERA) with communities during the engagement process for the SEA update. No formal public education strategy has been developed. NSE frequently presents information at educational institutions (schools, community colleges and universities) and other events. The Tidal Energy Toolkit (AETI 2013) provides additional information. This recommendation remains valid.
Recommendation 29: Long-term Integrated Management in the Bay The Province of Nova Scotia, partnering with New Brunswick, Canada, and the Gulf of Maine Council, study ICZM requirements, approaches and experiences, to provide the background for a major workshop to be held in 2009 to examine integrated management issues and organizational options for the Bay of Fundy.	NOT ADDRESSED. No specific ICZM workshop focused on the Bay of Fundy has been organized since 2008. This recommendation remains valid.

Statement of Qualifications and Limitations

The attached Report (the "Report") has been prepared by AECOM Canada Ltd. ("Consultant") for the benefit of OERA (the "Client") in accordance with the agreement between Consultant and Client, including the scope of work detailed therein (the "Agreement").

The information, data, recommendations and conclusions contained in the Report (collectively, the "Information"):

- is subject to the scope, schedule, and other constraints and limitations in the Agreement and the qualifications contained in the Report (the "Limitations");
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- may be based on information provided to Consultant which has not been independently verified;
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This Statement of Qualifications and Limitations is attached to and forms part of the Report and any use of the Report is subject to the terms hereof.

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List of Acronyms

AC	Alternating Current
ADCP	Acoustic Current Doppler Profiler
ACOA	Atlantic Canada Opportunities Agency
AOI	Area of Interest
ATEI	Acadia Tidal Energy Institute
BIO	Bedford Institute of Oceanography
BoF	Bay of Fundy
CDTF	Community Development Trust Fund
CEAA	Canadian Environmental Assessment Act
CEDIF	Community Economic Development Investment Fund
CHS	Canadian Hydrographic Service
CLC	Community Liaison Committee
CMER	Canadian-Marine Energy Research
COMFIT	Community Feed-in Tariff
CORE	Cornwall Ontario River Project
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
C-POD	Chelonia Porpoise Detector
DC	Direct Current
DFO	(Department of) Fisheries and Oceans Canada
EBSA	Ecologically and Biologically Significant Area
EDF	Electricité de France (a French electrical utility company)
EEM	Environmental Effects Monitoring
EEMP	Environmental Effects Monitoring Program
EGSPA	Environmental Goals and Sustainable Prosperity Act
EA	Environmental Assessment
EIA	Environmental Impact Assessment
EMAC	Environmental Monitoring Advisory Committee
EMEC	European Marine Energy Centre
EMF	Electromagnetic fields
ENGOs	Environmental Non-Government Organizations
ESSIM	Eastern Scotian Shelf Integrated Management
EPRI	Electric Power Research Institute
FAST	Fundy Applied Sensor Technology Project
FERN	Fundy Energy Research Network
FIT	Developmental Feed-in Tariff Program
FORCE	Fundy Ocean Research Centre for Energy
FTI	Fundy Tidal Inc.
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GIS	Geographic Information Systems
GW	Gigawatt (=1000 Megawatts)
GWh	Gigawatt hour
HADD	Harmful Alteration Damage or Destruction (of fish habitat)
HVdc	High Voltage Direct Current
IBA	Important Bird Area
ICM	Integrated Coastal Management
ICZM	Integrated Coastal Zone Management

IEA-OES	International Energy Agency – Ocean Energy Systems
ITQ	Individual Transferable Quota
KEI	Key Environmental Issues
KMKNO	Kwilmu'kw Maw-klusuagn Negotiation Office
Kts	Knots
kW	Kilowatt
kWh	Kilowatt Hour
LFA	Lobster Fishing Area
LiDAR	Light Detection and Ranging
LLC	Limited Liability Company
MCG	Mi'kmaw Conservation Group
MCT	Marine Current Turbines
MEA	Marine Energy Accelerator
MEKS	Mi'kmaq Ecological Knowledge Study
MOU	Memorandum of Understanding
MRC	Marine Renewables Canada
MRE	Marine Renewable Energy
MW	Megawatt (=1,000,000 watts)
NAFO	North Atlantic Fisheries Organization
NAREC	National Renewable Energy Centre/New and Renewable Energy Centre
NB	New Brunswick
NCC	Nature Conservancy of Canada
NHS	National Historic Site
NL	Newfoundland
NMBS	National Migratory Bird Sanctuary
NOTMAR	Coast Guard Notices to Mariners
NRC-IMB	National Research Council Institute for Marine Biosciences
NS	Nova Scotia
NSDFA	Nova Scotia Department of Fisheries and Aquaculture
NSDOE	Nova Scotia Department of Energy
NSEA	Nova Scotia Environment Act
NSERC	Natural Sciences and Engineering Research Council
NSNT	Nova Scotia Nature Trust
NSOAA	Nova Scotia Office of Aboriginal Affairs
NSPI	Nova Scotia Power Inc.
NWA	National Wildlife Area
OEER	Offshore Energy Environmental Research Association
OERA	Offshore Energy Research Association of Nova Scotia
OREG	Ocean Renewable Energy Group
ORPC	Ocean Renewable Power Company
PAM	Passive Acoustic Monitoring
PEI	Prince Edward Island
PoE	Pathways of Effects
PPAs	Power Purchase Agreements
PSF	Participation Support Fund
R&D	Research and Development
RAMSAR	Term used for an internationally designated wetland of significance (named after the town in Iran where the Convention on Wetlands was signed in 1971)
REA	Renewable Electricity Administrator

RFA	Recreational Fishing Area
RITE	Roosevelt Island Tidal Energy Project
RMA	Representative Marine Area
ROV	Remotely Operated Vehicle
RPM	Revolutions Per Minute
SARA	Species at Risk Act
SEA	Strategic Environmental Assessment
SFA	Scallop Fishing Area
SPA	Scallop Production Area
TAC	Total Allowable Catch
TISEC	Tidal In-Stream Energy Converter
UARB	(Nova Scotia) Utility and Review Board
UNESCO	United Nations Educational Scientific and Cultural Organization
VEC	Valued Ecosystem Component
WaveEc	Wave Energy Centre
WEC	Wave Energy Converter

PART A: Updated Background Report on Tidal Energy in the Bay of Fundy

1. Introduction

1.1 Project Overview

The Offshore Energy Research Association of Nova Scotia (OERA) has been retained by the Nova Scotia Department of Energy (NSDOE) to manage the Strategic Environmental Assessment (SEA) for tidal energy-based marine renewable energy projects in the Bay of Fundy. The SEA is an early step in the Province's incremental approach to developing Nova Scotia's tidal energy resources. In 2007 the NSDOE commissioned the OERA to complete a Phase I SEA to guide the development of tidal energy in the Bay of Fundy. The SEA was completed in 2008 and the Environmental Assessment for the Fundy Tidal Energy Demonstration Project began shortly after.

Since that time, there has been significant effort in support of a tidal energy industry in the Bay of Fundy. The OERA has commissioned this update to reflect the current state of industry development and associated research. To a large degree the industry has developed as specified in the 29 recommendations and 10 sustainability principles that resulted from the 2008 SEA process. Tidal energy related activity in Nova Scotia is proceeding in an incremental manner in the Bay of Fundy and Cape Breton. Renewable energy legislation, including legislation aimed at facilitating the commercialization of tidal energy, has been passed and new legislation is under consideration. The Province has committed to developing additional marine renewable energy legislation when the industry reaches commercialisation in Nova Scotia. The construction of the electrical substation and transmission line at the Fundy Ocean Research Centre for Energy (FORCE) combined with on-going research and monitoring programs attest to the commitment to tidal energy made by both the government and private industry.

At the same time, the tidal energy industry is evolving in ways not clearly foreseen in 2008. Two fundamental changes have occurred that will influence how tidal energy projects develop in Nova Scotia. First, demand for sites that can host arrays of turbines for commercial purposes (rather than for demonstration of their technologies, which have been tested elsewhere), is increasing.

A second contrast to the situation in 2008 is that the tidal energy industry has developed to service two distinct end-user markets. On the one hand, large utility-scale projects designed to transmit electricity for sale consist of large diameter turbine arrays deployed in high current, deep water environments. On the other hand, smaller scale, lighter units suited to lower current speeds can be deployed in shallow water nearer to shore with the ultimate objective of distributing electricity to local communities and other consumers.

In Nova Scotia, the differences between these two models are represented by the large-scale tidal energy project site in Minas Passage (FORCE), which ultimately aims to transmit power, compared to the smaller scale projects proposed near Digby and in Cape Breton, which aim to distribute power to the local communities. These two visions of commercial tidal energy will be explored in community forums as part of this Bay of Fundy SEA update.

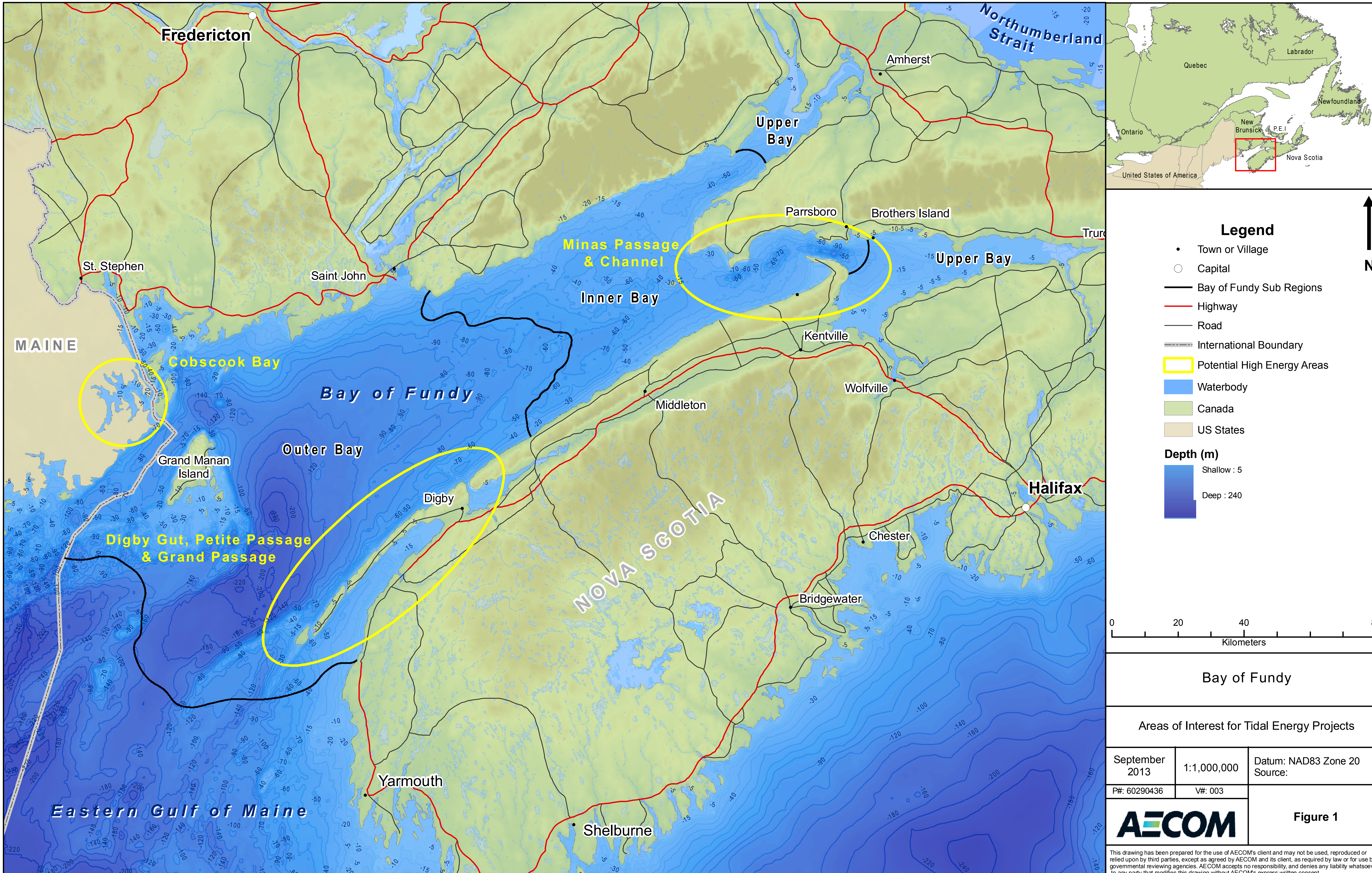
The 2008 Background Report described tidal energy technology, Nova Scotia's energy environment, the biophysical environment of the Bay of Fundy and the socio-economic context and benefits that may accrue from tidal energy development. But our understanding of these aspects has also evolved since 2008 – technologies have changed, regulations have been amended, resource estimates have been updated, and environmental effects monitoring programs have been completed or are ongoing. We have tried to capture in this updated report the changes to the industry since 2008 and present a synopsis of the environmental research and monitoring that has occurred over the past five years.

Finally, people's understanding and opinions regarding the social, economic and environmental effects of tidal energy may also have changed since 2008. The 2008 SEA Community Forums Report described several key themes of general interest to the stakeholders who participated in the SEA process. Among others, these themes include energy policy, tidal technology, ownership and investment, potential development scenarios, end uses of tidal energy, transmission capacity, biophysical and socio-economic effects and effects of the environment on the tidal turbines. As a second step in the updated SEA, stakeholder perceptions, concerns and ideas regarding these and other themes of general interest were again be explored through a series of Community Forums, and are summarized at the end this report.

Community engagement in 2013 also included the direct participation of Mi'kmaq organizations representing local Mi'kmaq communities. With the completion of the 2011 *Mi'kmaq Renewable Energy Strategy*, Mi'kmaq peoples are better informed and more heavily invested in the renewable energy industry than they were in 2008. Their vision, expectations and specific interests are valued contributions to the updated SEA Report.

Together, the updated Background Report and the outcome of the Community Forums have been compiled into a Final Updated SEA Report, for future use and reference by the public, academia, legislators and regulators. As requested by OERA, the overall outcome of the 2013 SEA Report is "to offer guidance and inform decisions on whether, where and under what circumstances to permit tidal energy development in the Bay of Fundy".

The project area is shown on Figure 1, which includes areas of interest for tidal energy development in the Bay of Fundy. Each area of interest is shown in greater detail on subsequent figures.


Fredericton
Northumberland Strait
Amherst
Upper Bay
Parrsboro
Brothers Island
Truro
Minas Passage & Channel
Upper Bay
Inner Bay
St. Stephen
Saint John
MAINE
Cobscook Bay
Bay of Fundy
Kentville
Wolfville
Middleton
Outer Bay
Grand Manan Island
Digby
Halifax
NOVA SCOTIA
Chester
Digby Gut, Petite Passage & Grand Passage
Bridgewater
Yarmouth
Eastern Gulf of Maine
Shelburne
Quebec
Labrador
Newfoundland
Ontario
New Brunsick
P.E.I
Nova Scotia
United States of America
Legend
Town or Village
Capital
Bay of Fundy Sub Regions
Highway
Road
International Boundary
Potential High Energy Areas
Waterbody
Canada
US States
Depth (m)
Shallow : 5
Deep : 240
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0 20 40 80
Kilometers
Bay of Fundy
Areas of Interest for Tidal Energy Projects
September 2013
1:1,000,000
Datum: NAD83 Zone 20
Source:
P#: 60290436
V#: 003
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Figure 1

1.1.1 Project Approach

The Updated SEA Report consists of an updated Background Study (**Part A**) and the Community Response Summary Report (**Part B**). The SEA Report was produced in two broad phases. The first phase focused on updating the Background Report to include an overview of recent tidal energy research and related activities conducted since 2008. This was completed first since this information formed the basis for discussions at the Community Forums. The second phase involved Community Forums, which began in August, 2013 with meetings with Mi'kmaq representatives and continued through October with a number of community meetings and presentations. Points of interest raised during the Community Forums are presented in the Community Response Summary Report, section 12 of this report.

The SEA process benefited from input by members of the Stakeholder Roundtable, a volunteer group composed of members representing fishers associations, environmental groups, academia, regulators, municipalities and project developers. The Roundtable was established early in the process to review and comment upon the Background Report and help guide the community consultation process. The project team is extremely grateful for the contributions from Roundtable members, and wishes to thank the group for their insight and support.

Stakeholder Roundtable Members	
1. Mr. Mark Taylor	Heavy Current Fishers Association
2. Mr. Wayne Groszko	Ecology Action Centre
3. Mr. Dana Morin	Fundy Tidal Inc.
4. Mr. Doug Keefe	Fundy Ocean Research Centre for Energy (FORCE)
5. Ms. Melissa Nevin	Kwilmu'kw Maw-klusuaqn Negotiation Office (KMKNO)
6. Mr. Donald Humphrey	Fisheries and Oceans Canada
7. Mr. Alan Howell	Nova Scotia Department of Energy
8. Mr. Terry Thibodeau	Municipality of Digby
9. Mr. Ian Watson	County of Kings
10. Ms. Sue Molloy	Dalhousie University / Glas Ocean Engineering Consulting
11. Ms. Kathleen Kevany	Dalhousie University
12. Mr. Vance Hazelton	Full Bay Scallop Assoc. and Digby Wharf Committee
13. Mr. Stephen Ferguson	Municipality of the County of Cumberland

The project team consists of AECOM Canada Ltd. (AECOM) in partnership with the Acadia Tidal Energy Institute (ATEI). The people engaged to complete this work are:

Acadia Tidal Energy Institute

- Dr. Anna Redden
- Dr. Graham Daborn
- Dr. Richard Karsten
- Dr. John Colton
- Lisa Isaacman
- Monica Reid
- Cody MacGregor

AECOM Canada Ltd.

- Russell Dmytriw
- Candace Harding
- Cory McPhee
- Timothy Bachiu
- Iain Bell (UK)
- Rayna Carmichael
- Karen Verney

Please note that underlined, blue text is hyperlinked to the document referenced. If this report is being read on an internet-connected computer, please click on the underlined blue text to access the linked document.

2. Nova Scotia's Renewable Energy Context

Section Summary

This section presents the current renewable energy landscape in Nova Scotia, and describes the regulations, policies and initiatives designed to aid the development of renewable energy in the province. Beginning with an overview of renewable electricity regulation, the section describes community and developmental feed-in tariffs, and other initiatives undertaken specifically to promote marine renewable energy. Strategic Environmental Assessments are described, as well as the legislation governing tidal projects and permitting requirements for specific projects. The section closes with a description of the province's current energy mix, NSPI's transmission grid, and the challenges and opportunities for integrating renewable energy into the grid.

2.1 2007 Environmental Goals and Sustainable Prosperity Act (EGSPA)

In 2007, the Nova Scotia Government passed the *Environmental Goals and Sustainable Prosperity Act* (*EGSPA*), an innovative piece of legislation on sustainable development and economic prosperity. EGSPA sets out 21 goals and two overarching objectives to be reached by 2020. EGSPA contains the first hard caps of greenhouse gas (GHG) emissions in Canada (NSE 2010). Among other actions, the *Act* calls for a reduction in GHGs of 10% below 1990 levels by the year 2020.

2.2 Overview of Nova Scotia's Energy Goals

In order to lessen the province's dependency on imported fossil fuels and reduce greenhouse gas and air pollutant emissions, the Government of Nova Scotia tabled *Toward a Greener Future - Nova Scotia's 2009 Energy Strategy* followed by the 2010 *Renewable Electricity Plan*. These reports describe an approach to integrate progressively larger amounts of low-emission renewable energy into the provincial electrical grid. At the same time, development of the renewable energy industry is expected to bring employment opportunities and other economic benefits to Nova Scotia.

Following public consultation in 2010, renewable electricity targets were enacted into law through the provincial *Renewable Electricity Regulations* made under the *Electricity Act.* The *Regulations* require 25% of the electricity consumed in Nova Scotia to be generated from renewable sources by 2015. By 2020, this requirement rises to 40%. An estimated 1,700 GWh of new renewable electricity will be needed to meet the legislated 2015 targets[1]. To achieve the 2020 targets, a further 1,800 GWh of renewable electricity will be required on an annual basis (NSDOE 2010).

While it appears that the 2015 renewable electricity targets can be met with modest investments in transmission infrastructure and careful management of electrical loads on the existing grid, meeting future targets will require new lines to serve remote project locations, increased line capacity to deliver newly-produced renewable electricity, and modifications to infrastructure that will allow accommodation of intermittent wind and tidal power (NSDOE 2010).

The sections below describe the policies, acts and regulations enacted to initiate and support renewable energy in Nova Scotia, with a focus on the development of the tidal energy industry.

[1] The closure of the Bowater Mersey Paper Company mill in 2012 and the forecasted closure of the Imperial Refinery in Dartmouth reduces the amount of electricity that NSPI needs to produce, and therefore the amount of renewable energy that will need to be integrated into the system to meet these targets (NSPI 2012; Power Advisory 2013).

2.3 Nova Scotia Energy Policy Reports

2.3.1 Toward a Greener Future: Nova Scotia's 2009 Energy Strategy

The 2009 *Energy Strategy* presents a variety of policy steps to encourage energy conservation, increase renewables, and diversify Nova Scotia's energy supply (NSDOE 2009a). These steps include:

- Encouraging and creating new opportunities for small-scale producers of electricity from renewable sources;
- Acting on commitments made in response to the 2008 tidal SEA;
- Beginning a "Green Grid" Initiative to encourage transmission grid expansion, assess opportunities to strengthen grid connections, and study options for grid upgrades;
- Investing in associations, programs and projects focused on energy technologies, research and development;
- Continuing the consultation on sustainable energy policy; and,
- Creating marine renewable energy legislation.

2.3.2 2010 Renewable Electricity Plan

In preparation for the *Renewable Electricity Plan*, the Nova Scotia Renewable Energy Steering Committee led by Dr. David Wheeler of Dalhousie University facilitated a series of public consultations in the summer and fall of 2009. The objective of the work was to develop a strategy to achieve the Province's renewable energy goals over the short term and help build Nova Scotia's competitive economic advantage in marine renewable technology and services over the longer term.

The *Renewable Electricity Plan* describes three initiatives that will be implemented to meet the renewable energy targets:

- An Enhanced Net Metering Program, by which individuals can receive payment for the extra renewable electricity they produce while powering their home or business. Qualifying projects may be up to 1 MW in size;

- A series of feed-in tariffs (guaranteed prices paid by NSPI to power producers), one for community-based entities and one for developmental (large scale) tidal projects:

  - The Community Feed-in Tariff (COMFIT) program that pays fixed rates for electricity generated from small-scale energy projects owned by community-based entities such as Aboriginal groups, municipalities, co-operatives, universities, community economic development investment funds (CEDIFs) and non-profit groups. These wind, biomass, hydroelectric and tidal energy projects are small in size since they are connected to the local distribution grid, ensuring the power they produce stays within the local community; and,

  - A Developmental Tidal Feed-in Tariff (FIT) program, which establishes rates per kilowatt hour for larger scale developmental tidal projects. The FIT program is intended to offset a portion of the costs of these projects and encourage research and development in Nova Scotia's tidal energy industry. The UARB is expected to set the rate for these projects in fall 2013. Developmental tidal projects are currently defined as those projects that are greater than 500 kW in capacity and are connected to Nova Scotia's transmission grid.

- A Renewable Energy Administrator (REA) to supervise Independent Power Producer competitions for medium and large scale renewable electricity projects. A total of 300 GWh was allocated to these larger projects.

The *Plan* sets out a detailed program to help transition Nova Scotia away from largely carbon-based electricity towards greener, more local sources. Under the *Plan*, NSPI renewable energy projects will continue to be evaluated and approved by the Utility and Review Board (UARB), while Independent Power Producers will compete for projects in a bidding process managed by the newly appointed REA. The REA was appointed in July 2011 and began accepting proposals for new projects from Independent Power Producers in September 2011. In August 2012, 115.8 MW of new renewable energy projects were approved.

2.4 2010 Electricity Act and Renewable Electricity Regulations

Following the release of the *Renewable Electricity Plan,* legislative amendments were made to the *Electricity Act* and the *Renewable Electricity Regulations*. These changes were made to provide a legal foundation for the policies presented in the *Plan*. In May, 2010 the draft regulations were released for public comment and in June/July, 2010, a province-wide consultation process was conducted to receive feedback on the regulations.

In October, 2010 the amendments to the *Act* were proclaimed and the regulations enacted. The *Renewable Electricity Regulations* provide the legislative framework to put many of the commitments, tools and programs under the *Renewable Electricity Plan* into action. This includes the Enhanced Net Metering Program, COMFIT, and the setting of FIT rates. The *Regulations* also set in law the future renewable electricity standards articulated in the *Renewable Electricity Plan*: 5% renewable energy by 2011; 10% by 2013, 25% by 2015 and 40% by 2020.

Over the longer term, changes to legislation will potentially address:

- Economic regulation to help retain benefits from commercial renewable energy development;
- Land tenure;
- Regulatory approvals, licensing and permits; and,
- Safety issues.

2.4.1 COMFIT Program

As noted, the COMFIT program allows eligible community groups to receive a fixed price per kilowatt hour (kWh) for community projects producing electricity from wind, biomass, in-stream tidal and run-of-the river hydroelectric developments. The COMFIT program is restricted to relatively small scale projects, generally under 6 MW, but approximately 100 MW is expected to be connected to Nova Scotia's distribution grid through this program. The COMFIT rate of tidal energy projects is 65.2 cents per kilowatt hour.

As of September, 2012, more than 100 community-based COMFIT proposals had been received from more than 20 community groups. Of these, five COMFIT applications are specific to small scale tidal energy development. These tidal projects were awarded to Fundy Tidal Inc. (Fundy Tidal) for in-stream tidal projects in Great Bras d'Or Channel (500 kW), Barra Strait (100 kW), Grand Passage (500 kW), Petit Passage (500 kW) and Digby Gut (1.95 MW). Fundy Tidal Inc. seeks to operate through a Community Economic Development Investment Fund[2] (CEDIF) supported by community shareholders. Research funding to support these COMFIT projects has been received from Natural Resources Canada (NRCAN), the Natural Sciences and Engineering Research Council (NSERC), Atlantic Canada Opportunities Agency (ACOA), Nova Scotia Department of Fisheries and Aquaculture (NSDFA), OERA, and the Nova Scotia Department of Economic and Rural Development and Tourism.

At present, Fundy Tidal is assessing technology providers for its COMFIT projects. COMFIT approvals for tidal energy projects require that the projects are operational within five years from the time of approval. As a part of

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[2] *A CEDIF is a pool of capital, formed through the sale of shares, to persons within a defined community, created to operate or invest in local business.*

Nova Scotia's *Marine Renewable Energy Strategy*, Fundy Tidal will work with the Province to establish these sites as focal points for research and commercial tidal industry development, as well as to enable the demonstration of innovative ocean technologies – one of the concepts outlined in the *Marine Renewable Energy Technology Roadmap* (S. Farwell, pers. comm. 2013).

2.4.2 Development Tidal FIT Program

The COMFIT program is limited to technologies having a maximum output of 500 kW, which restricts COMFIT project developers from deploying the larger devices increasingly available on the market. The Developmental Tidal FIT program will allow eligible proponents (private developers) of larger-scale projects to receive a fixed price per kWh for the electricity produced incidental to testing and development of their device(s). Developmental tidal projects are defined as those projects that are greater than 500 kW in capacity and are connected to Nova Scotia's electrical grid. The fixed rate for developmental tidal projects will serve as an incentive to encourage research and development in Nova Scotia's tidal energy industry. At the present time, rates for large scale tidal energy have not been set. FIT rates are expected to be finalized in late 2013.

Commercial-scale machines in the 1.0-2.0 MW range offer a potential economic advantage, since the sale of the power they generate can be used to offset the cost of manufacturing and installing the devices. This economic opportunity, in turn, helps to attract the capital investment needed to develop the commercial scale technology. The Development Tidal FIT program is intended to help offset the costs of these larger scale commercial tidal projects.

2.5 2011 Fournier Report on MRE Legislation

In mid-2011, the Government of Nova Scotia released the Fournier Report on *Marine Renewable Energy Legislation* (Fournier 2011). Dr. Robert Fournier, a Dalhousie University Oceanographer, was commissioned to lead a public consultation process regarding options for marine renewable energy legislation. The report prepared upon conclusion of the consultation process included 27 recommendations for the creation of future policy and legislation, organized into four categories – planning, economic opportunities, research, and regulation. One of the most significant recommendations was for the development of a strategic plan for marine renewable energy, with an emphasis on in-stream tidal energy.

2.6 2011 Marine Renewable Energy Technology Roadmap

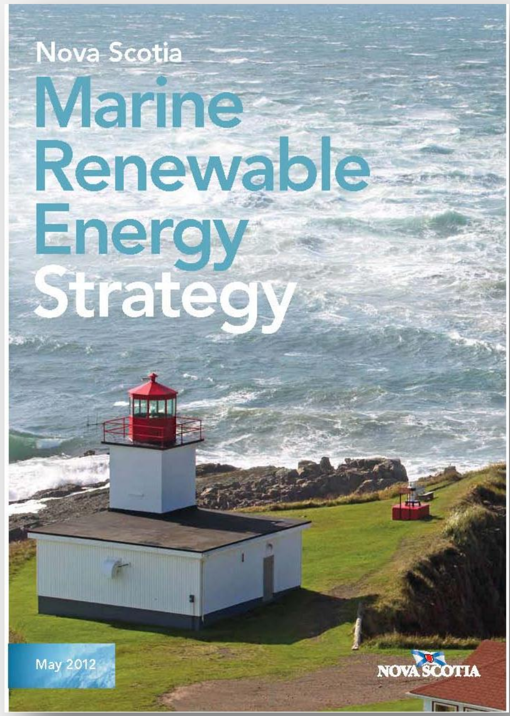
To help define the path to build a national marine renewable energy industry, the Ocean Renewable Energy Group (OREG, now Marine Renewables Canada) initiated the *Marine Renewable Energy Technology Roadmap* in late 2011. Marine Renewables Canada is a national marine energy industry association working to promote all forms of marine renewable energy within Canada. The *Roadmap* was federally funded by NRCan and prepared under the direction of the MRE Technology Roadmap Steering Committee composed of industry, academic, federal and provincial government representatives. The Committee conducted workshops across the country between February and June 2011 to gather information from MRE industry and academic participants.

The *Roadmap* articulates a vision of Canada's leadership role in marine renewable energy, describes the pathways to achieving that goal, and defines the activities that must be undertaken to achieve economic gains by leveraging the country's strengths to build domestic capacity.

2.7 2012 Marine Renewable Energy Strategy

Marine Renewable Energy Strategy

The *Marine Renewable Energy Strategy* outlines plans and timetables to address provincial research, development and regulatory priorities to promote the growth of the tidal energy industry.



Following on the recommendations in the Fournier Report and the *Marine Renewable Energy Technology Roadmap,* Nova Scotia's *Marine Renewable Energy Strategy* was released in May, 2012. The *Strategy'*s goals are to (a) support the growth of the local marine renewable energy (MRE) industry and (b) develop Nova Scotian knowledge and technologies for use and export. The *Strategy* outlines the economic, legal and policy conditions needed to advance the MRE industry in Nova Scotia and capitalize on opportunities for investment and economic growth.

The *Strategy* is based on three fundamental concepts: building trust through scientific accountability and transparency; ensuring economic and environmental sustainability over the long term, and achieving economic growth through Nova Scotia's participation in the global MRE supply chain (B. Cameron, pers. comm. 2013).

The *Strategy* presents three overarching plans to address research, development and regulatory initiatives.

- A Research Plan. Research will be used to establish priorities and address knowledge gaps. Researchers will form collaborative partnerships with technology developers and others involved in the industry, solicit funding for research priorities and help build a competitive industry in Nova Scotia;

- A Development Plan. The tidal industry will be expanded using innovative partnerships, investment in monitoring and servicing technologies, feed-in tariffs, and the promotion of technology incubation sites. The Province will encourage MRE projects by assisting technology development for both large and small-scale tidal projects, opening markets to electricity and helping to build a Nova Scotia-based supply chain for tidal power; and,

- A Regulatory Plan. The Province will develop a legislative framework and regulatory system to help licensing, environmental assessment and protection, community benefits and provincial tax revenue. This will entail new regulations, a robust approvals and licensing oversight system, and a comprehensive stakeholder engagement plan.

In the *Strategy*, the Province committed to ensuring that the total impact on ratepayers for the Developmental Tidal FITs would be no higher than 2%. The FIT for single tidal devices will apply only to projects deployed at FORCE. The FIT for tidal arrays will not be limited to a particular area but will be limited through the 1-2% calculation.

After the Developmental FITs are set by the UARB in late 2013, NSDOE will manage the available capacity through an approval process to be outlined in upcoming amendments to the *Renewable Electricity Regulations*. A discussion paper on the application process was released in August 2013. Recipients of the FIT approval will enter into a Power Purchase Agreement with NSPI to receive the FIT for the power they produce. The UARB will establish the time period covered by the Power Purchase Agreement.

2.8 Provincial Perspective on Industry Development

The government of the Province of Nova Scotia is committed to implementing the *Marine Renewable Energy Strategy*, achieving incremental tidal energy development, and ultimately building a Nova Scotia-based tidal energy service industry. To this end, the FORCE Tidal Demonstration Project and COMFIT sites in the Digby area are conceived as technology and service incubators for this young industry. Commercial-scale tidal energy will be approached through a series of steps. Critical early phases (e.g. resource assessment) have been completed in Minas Passage and in the Digby area. At the same time, a regulatory and policy framework has been established that clarifies the road to commercialisation and prioritizes government investment in research and supporting infrastructure. The provincial government, with the support of federal departments and federal level economic development agencies, is working to build a tidal energy industry focused not only on the commercial extraction of energy for internal use and export, but on the long-term economic benefits that may be achieved by building innovative tools, technologies and services to support this industry in the global marketplace.

NSDOE has completed or is currently working on a number of initiatives to develop and promote the tidal energy industry in Nova Scotia. These include:

- Initiating a request for proposals to attract project developers interested in the fourth berth at the FORCE site (the request for proposals period closes December 16, 2013);
- Supporting and partially funding FORCE;
- Establishing a partnership with DFO to pursue regulatory priorities and resolve regulatory obstacles to project development, such as the *Statement of Best Practice for In-Stream Tidal Energy Development and Operation*;
- Establishing ongoing UK, European and Asian collaboration;
- Contributing to MRE supplier and developer workshops, conferences and technical presentations;
- Establishing COMFIT rates and engaging in community consultation to establish Developmental FIT rates for tidal energy projects later in 2013;
- Through the OERA, NSDOE[3] supports tidal energy research in priority areas, including the recently completed Southwest Nova Tidal Resource Characterization Project that identifies additional potential sites for tidal energy projects. OERA has also supported a socioeconomic scoping study, a tidal energy toolkit for community and business use, a community engagement handbook with practicable applications in future tidal energy projects, research symposia and other tidal energy forums. OERA has recently initiated a project to examine the value proposition of tidal energy development to the marine technology industry locally, regionally and nationally; and,
- NSDOE through OERA is funding the current *Update to the Bay of Fundy SEA* and has initiated a similar SEA for marine renewable energy in Cape Breton.

Efforts to develop this industry in Nova Scotia have also benefited from funding received from the federal Clean Energy Fund, the ecoENERGY Innovation Initiative, and the Sustainable Development Technology Corporation (SDTC).

Collaboration with research and development activities in other jurisdictions acts to multiply the effects of local investment, as findings are exchanged and lessons learned are transferred between projects. At the federal level, a Canada – UK Declaration promotes biannual coordination meetings to develop joint research programs and

[3] *NSDOE commissions and funds OERA to initiate research on offshore energy issues. NSDOE does not direct OERA research activities.*

regulations. At the provincial level, OERA has recently undertaken a priority/goal setting process and currently has an information sharing agreement with the European Union. FORCE has a Memorandum of Understanding with the European Marine Energy Centre (EMEC) in Scotland; Dalhousie and Acadia Universities have partnerships with European universities that are fostering research on marine renewable energy issues. NSDOE is also committed to collaborating with national and international organizations to maximize benefits from research and investment, and communicate Nova Scotia's potential tidal resource and the capabilities of our marine services industry. NSDOE is a supporter of the Canadian Subcommittee of IEC TC 114 created to prepare international standards for marine energy conversion systems. The Province has also signed Memoranda of Understanding (MOUs) with the State of Maine and the Province of British Columbia to facilitate cooperation on tidal energy project development research.

At the current time, constraints to tidal energy development in Nova Scotia include the global lack of venture capital funding, challenging environmental conditions, the small size of the local electrical market, and limitations to the amount of new energy that can be accommodated onto the existing electrical grid. Federal funding may be needed to subsidize the capital costs of tidal array projects, but ultimately, commercially-delivered tidal energy must be produced at market rates to build a sustainable, profitable tidal energy industry (S. Farwell, NSDOE pers. comm. 2013).

2.9 Mi'kmaq Participation in Renewable Energy Strategies

In 2011, the Government of Nova Scotia funded the development of a Mi'kmaq-specific renewable energy strategy. The *Mi'kmaq Renewable Energy Strategy* supports the Assembly of Nova Scotia Mi'kmaq Chiefs in pursuing direct and indirect renewable energy opportunities in Nova Scotia, ensuring the participation of the Mi'kmaq of Nova Scotia in the growing renewable energy sector. Upon receipt of the *Strategy*, the five Cape Breton bands enacted a pilot home energy audit program to find the root causes for higher energy usage in their communities. One of the program's goals is to determine effective ways to mitigate the problem (Mi'kmaq Rights Initiative, undated).

The Nova Scotia Department of Energy has also funded the hire of an Energy Advisor to work at the Kwilmu'kw Maw-klusuaqn Negotiation Office (KMKNO) to provide energy sector technical and policy support capacity to the Assembly. Additionally, the Department has hired an Aboriginal Business Development Officer to work with the KMKNO and Nova Scotia's Mi'kmaq communities to assist in exploring potential energy sector prospects. These initiatives build Mi'kmaq capacity on energy issues and will help the Assembly identify energy sector business opportunities and implement the *Strategy* (NSDOE 2012).

In 2012 the Assembly of Nova Scotia Mi'kmaq Chiefs was successful in securing two COMFIT awards which in total amount to 10 MW of wind power. With project sites located in Whynotts Settlement and Amherst, it is anticipated that both projects will be fully commissioned by 2015. In June 2012, the Assembly launched the Mi'kmaq Energy Efficiency Program (in partnership with Efficiency Nova Scotia) to reduce the electricity consumption in the thirteen Mi'kmaq communities. The reduction in energy usage will be achieved through installations of energy efficient products and is anticipated to be complete by October 2013.

The marine resources used by tidal energy projects are shared with local communities including the Mi'kmaq First Nations along the Bay of Fundy. The Mi'kmaq have key roles in the development process including opportunities for investment and knowledge of marine use areas.

The government has a duty to consult First Nations when proposed activities have the potential to impact Aboriginal rights, including title and treaty rights. Tidal energy development is considered in this context because of the potential impacts to the use of marine resources by Nova Scotia Mi'kmaq. The Nova Scotia Office of Aboriginal Affairs (NSOAA) has issued a revised summary of the consultation process (NSOAA 2012). The consultation process offers an opportunity to identify potential impacts including those related to socio-economic issues.

In 2011, the Mi'kmaq of Nova Scotia investigated renewable energy options for electricity supply to local communities and as potential for income generation through the COMFIT program (Campbell 2011). As MRE develops, Mi'kmaq communities may choose to engage in development opportunities through COMFIT programs.

Social and cultural impacts from tidal energy development may occur through changes in the marine environment and resources harvested there, and access restrictions to tidal energy project areas. To identify resource use and address the potential for land use conflict, two Mi'kmaq Ecological Knowledge Studies (MEKS) were completed in and around the Bay of Fundy. MEKS assess the potential impacts to Mi'kmaq people by examining their land and resource use practices and traditional knowledge of the Mi'kmaq people. Data presented in the MEKS were gathered from interviews with Mi'kmaq individuals who reside in the surrounding Mi'kmaq communities and those who are familiar with or undertake traditional use activities in this area.

The Phase I MEKS (MGS 2009) assessed areas around the Fundy Tidal Energy Demonstration project (now FORCE) in Minas Passage. Land use, both current and historical, as well as resource utilization was assessed for three zones: the Project Area – the location of the project site, the Study Area – a 10 km radius around the Project Area, and the Phase I Area, which covers part of Chignecto Bay, Greville Bay, Minas Channel and a large portion of the Minas Basin. The Phase I MEKS reported ongoing and past commercial fishing of lobster, mackerel, herring and halibut at the Project Site. Within the Study Area, harvesting of fish species, plants and animals occurred in the past and continues to occur at varying times of the year. Loss of any species or destruction of habitat by tidal development may impact Mi'kmaq resource use. The sole recommendation from the report states:

> *In consideration that the Mi'kmaq undertake fishing activity, for commercial and harvest, directly within the Project Site where the turbines are to be built as well as in various locations throughout the Study Area, it is recommended that the proponent meet with the Assembly of Nova Scotia Mi'kmaq Chiefs to determine possible future steps to be taken in regards to Mi'kmaq use of the area.*

The Phase II MEKS report examines the areas in the Outer Bay of Fundy (MGS 2012). The scope of assessment includes potential tidal energy 'Project Sites' – Digby Gut, the southern tip of Digby Neck, the southern tip of Long Island and southwest Brier Island; 'Study Areas' within a 5 km radius of the Project Sites; and the 'Phase II Study Area' which includes the Bay of Fundy surrounding the Project Sites and inland areas. Results of the Phase II MEKS report indicate that fishing, hunting and gathering activities have occurred in the past and continue to occur in the Project Sites, Study Areas and Phase II Study Area. Specifically, lobster, mackerel and clams are the primary marine harvesting activities. Again, the report recommends tidal energy project proponents meet with the Assembly of Nova Scotia Mi'kmaq Chiefs to determine possible future steps to be taken in regards to Mi'kmaq use of these areas.

2.10 Strategic Environmental Assessments (SEA) and Applicable Regulations

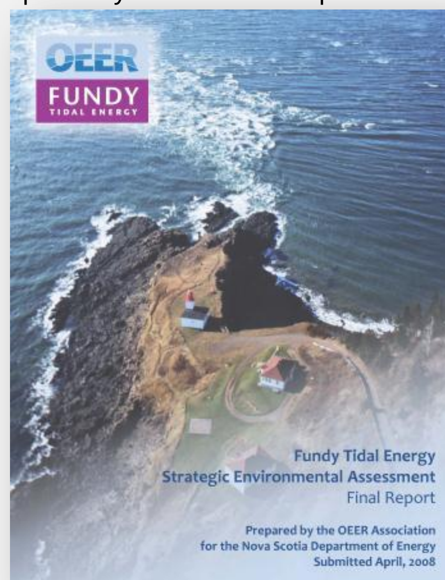
2.10.1 Bay of Fundy SEA

Work undertaken by the Electric Power Research Institute (EPRI) on behalf of the NSDOE and Nova Scotia Power Inc. (NSPI) in 2006 identified Nova Scotia as one of the most promising locations for tidal power generation in North America. In 2007, the NSDOE commissioned the Offshore Energy Environmental Research Association (OEER, now OERA) to complete a Phase I Strategic Environmental Assessment (SEA) to guide the development of marine renewable energy in the Bay of Fundy. The Phase I SEA for the Bay of Fundy was completed in 2008.

A SEA is a type of regional environmental assessment carried out before decisions are made about specific projects. The SEA is a comprehensive assessment of an entire industry, and is much broader in scope than a typical Environmental Assessment, which is more narrowly focused on the effects of a single project. SEAs are required by the Province before any permits, approvals or development licenses are issued. They provide a starting point from which future projects can be considered; they describe the current state of knowledge regarding the effects of the technology on the environment, and the environment on the technology. They also report public opinion and local knowledge about natural resources, the regional environment and potential issues that MRE projects may encounter when developed (NSDOE 2012).

Phase I Bay of Fundy SEA (2008)

The SEA assesses the environmental and social impacts of future MRE projects and provides stakeholders with an early opportunity to influence decisions related to planning, policies, regulation, and management before specific projects are allowed to proceed. The final report may be found at: http://www.oera.ca



Recommendations made at the conclusion of the 2008 SEA are presented in **Appendix A.** Each recommendation has been updated with text to indicate whether it was addressed, how it was addressed, and whether it remains a valid recommendation in 2013.

2.10.2 Cape Breton and Bras d'Or Lakes SEA

With the introduction of the COMFIT program, two potential tidal energy sites in Cape Breton were awarded to Fundy Tidal. To guide the development of these and other marine renewable energy projects, the Province in 2012 commissioned OERA to complete a Phase II SEA for coastal Cape Breton and the Bras D'Or Lakes. The Background Report to the SEA, which was expanded to include other forms of marine renewable energy such as offshore wind and wave power, was completed in 2012. The community consultation stage of the Phase II SEA is currently underway in Cape Breton and is expected to be completed in late 2013.

The Cape Breton region SEA Background Report identified a number of environmental and socio-economic subjects of interest regarding MRE projects, and identified potential MRE project sites in the region. The Background Report also provides a summary of data gaps that will need to be addressed if MRE projects are to receive regulatory approval in the future and makes recommendations to address information gaps identified during the study. These knowledge gaps were generally in one of two categories: outstanding questions regarding the nature and extent of certain interactions between MRE technologies and marine biota; and a general lack of detailed information describing baseline biophysical conditions, especially in coastal areas. The on-going community consultation portion of the Phase II SEA will provide a forum for information exchange, solicitation of questions and concerns, and identification of additional area-use conflicts that may exist. The final report may be found at: http://www.oera.ca.

2.10.3 Canadian Environmental Assessment Act (CEAA)

The *CEAA* was passed in 1995 and is one of the primary federal laws used to promote sustainable development and prevent environmental degradation. In 2012 the federal *Budget Implementation Bill* was tabled, modifying more than 60 laws and regulations including *CEAA*, the *Fisheries Act* and the *Navigable Waters Protection Act*.

The *Budget Implementation Bill* repealed *CEAA* and replaced it with a new piece of legislation, *CEAA, 2012,* which came into force on July 6, 2012. One of the most significant changes is the move away from the "trigger" approach, whereby an environmental assessment was automatically triggered whenever a federal agency was required to grant a permit, provide funding, act as the proponent or when it owned the land on which the project is located. The new *Act* takes a "project list" approach, where an assessment is only required for specific types of projects designated in the *Regulations Designating Physical Activities.* Additionally, *CEAA 2012* limits the number of factors that must be considered in assessments to only those matters of federal jurisdiction, such as fish, aquatic species-at-risk, migratory birds, projects on federal lands, and effects on Aboriginal peoples.

Under the current *Regulations Designating Physical Activities,* in-stream tidal power generating facilities with a production capacity of 50 MW or more are subject to the *CEAA* and will require a federal environmental assessment[4]. The current production capacity threshold for other types of tidal power generating facilities, such as tidal lagoons and tidal barrages, is 5 MW; larger projects would require a federal environmental assessment.

2.10.4 Fisheries Act

The *Fisheries Act* was first enacted in 1868, empowering the federal government to protect oceans, fresh water environments, fish and fish habitat. Under subsection 35(1), it is an offence to carry on any work or undertaking that results in harmful alteration, disruption or destruction (HADD) of fish habitat. Under subsection 35(2), a HADD authorization granted by the Fisheries and Oceans Canada (DFO) is required prior to any work or undertaking that would result in a HADD of fish habitat. This would apply to most tidal energy projects that use gravity base structures since these structures rest on the seabed and occupy fish habitat. It could also apply to projects that are of a large enough to affect surrounding habitats through changes in energy flow (e.g. scouring, tidal height changes, sedimentation). Section 32 of the *Act* prohibits the killing of fish by means other than fishing, ensuring the federal government's ongoing responsibility to oversee operational tidal projects. Finally, Sections 20 and 22 of the *Act* regulates obstructions to fish passage. The sections may be invoked in the case of tidal arrays installed in narrow passages and/or for tidal lagoon-type projects where there is a potential that fish passage is prevented or impeded.

The 2012 federal *Budget Implementation Bill* introduced a number of changes to the *Fisheries Act*, particularly to those provisions related to habitat protection (Section 35) and the killing of fish (Section 32). While the changes are not yet in force, they will effectively combine these two prohibitions into a single new fisheries protection prohibition that will prevent serious harm to fish that are part of, or support, a commercial, recreational or Aboriginal fishery. The new prohibition will still provide protection for fish and fish habitat as the term "serious harm" has been defined as "the death of fish or any permanent alteration to, or destruction of, fish habitat." However, the new prohibition will refocus DFO's efforts on those activities that pose the greatest threat to the sustainability and productivity of Canada's commercial, recreational and Aboriginal fisheries. The proposed changes to the *Act* are expected to be enacted prior to 2014. Authorizations will still be required for works, activities and undertakings resulting in a contravention of the new prohibition, committing the proponents of tidal energy projects to meet certain regulatory requirements such as habitat avoidance, mitigation, habitat compensation and monitoring.

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[4] *Section 67 of CEAA 2012 requires an "environmental effects determination" for projects on federal lands where a federal decision is involved. The Bay of Fundy is generally considered provincial lands but this requirement may apply for some projects in certain harbours where Transport Canada owns submerged lands (e.g., around Digby).*

In June 2012, DFO announced they will work to develop a new *Fisheries Protection Policy* and a regulatory plan to support changes to the *Fisheries Act*, as well as to provide a foundation for a new Fisheries Protection Program. An updated *Fisheries Protection Policy* is being prepared to replace the 1986 *Policy for the Management of Fish Habitat Management.*

2.10.5 Navigable Waters Protection Act (NWPA)

The *Navigable Waters Protection Act* (*NWPA*) was first established in 1882 to protect the right of Canadians to navigate through the country's waterways without interference from industrial development. Developments in or above navigable waters require review by Transport Canada, and issuance of a permit to ensure navigation hazards are appropriately identified and communicated to other users of the waterway. Proposed amendments under the *Budget Implementation Bill* include changing the name to the *Navigation Protection Act*, as well as excluding most of Canada's lakes and rivers from specific regulation under the *Act*. Although *NWPA* approvals would no longer trigger a federal environmental assessment, approvals would still be required for works in all navigable waterways.

2.10.6 Nova Scotia Environment Act and Associated Regulations

Enacted in 1995, Nova Scotia's *Environment Act* (*NSEA*) is the mechanism granting the Nova Scotia Department of Environment the power to create, implement and enforce regulations, approvals, policies and programs that protect the environment. The *Environmental Assessment Regulations* under the *Act* require that MRE projects with a production rating of at least 2 MW are registered as Class I Undertakings and undergo environmental assessment Currently, there are no plans to change the 2.0 MW environmental assessment trigger for tidal energy projects; however, a future high level, comprehensive review of the assessment process is being contemplated by the department (P. Geddes, pers. comm. 2013).

2.10.7 Regulatory Summary

In summary, a SEA is a high level environmental assessment process intended to improve planning and inform decision making prior to allowing an industry or group of projects to take place in a specific area. By policy, the Province has made SEAs a prerequisite to the development of MRE projects in Nova Scotia. For projects in the Bay of Fundy, coastal Cape Breton and the Bras d'Or Lakes, in-stream tidal power generating stations with a production capacity of 50 MW or more currently require federal environmental assessment. Tidal barrage-type projects of 5 MW or more require a federal assessment.

Under Nova Scotia regulations, tidal stations with a production capacity of 2 MW or more require environmental assessment. These requirements will apply to any large scale tidal generating projects. However, small-scale MRE projects, comparable those covered under the COMFIT program, likely will not require federal or provincial environmental assessment, but will likely remain subject to approvals under the *Fisheries Act* and *Navigable Waters Protection Act / Navigation Protection Act*, among others.

2.11 Conventional and Renewable Energy in Nova Scotia

2.11.1 Current Energy Mix and Security

Nova Scotians are among the highest per capita consumers of electricity in the world (NSDOE 2009a). The 450,000 business and residential users currently consume approximately 12,000 gigawatt hour (GWh) of electricity annually, of which about 11% came from renewable sources in 2010 and approximately 17% from these sources in 2012 (NSDOE 2010; NSPI 2012a). Nova Scotia natural gas contributed 20% of the province's power needs in 2011 and is expected to contribute 21% in 2013 (NSDOE 2012).

The province uses a peak load of about 2,200 megawatt (MW) of electricity during cold winter periods and approximately 700 MW on warm summer evenings. Given that the province has only limited links to additional power sources in the rest of Canada (see below), Nova Scotia is essentially isolated from these sources and must produce nearly all the electricity it consumes.

NSPI generates electricity for the province using coal, petroleum coke ('petcoke'), oil, hydro, natural gas, biomass, tidal and wind. The company also purchases electricity from Independent Power Producers through long-term power purchase agreements and out-of-province day ahead ("forward") markets to meet its customers' needs, and sells surplus electricity to out-of-province forward markets (Hatch 2008). In 2011, approximately 63% of Nova Scotia's electricity supply was generated from imported coal, petroleum coke, fuel oil, along with other energy imports, while the remainder came from natural gas and renewable sources such as hydro, wind and tidal power (NSDOE 2012). The government of Nova Scotia has long realized that the over-reliance on imported coal and oil exposes the province to extreme international price fluctuations, potential disruption in supply and excessive greenhouse gas and air pollutant emissions (NSDOE 2009a).

Nova Scotia has four coal and petroleum coke-fired generating stations with a combined installed capacity of 1,252 MW (Nova Scotia Power in SLR 2010). Oil, diesel and natural gas provide an additional 637 MW. To supplement the power generated at these stations, Nova Scotia has 33 hydro generating stations with a combined installed capacity of 360 MW. The Annapolis Tidal Power Plant, one of only three such stations in the world, adds an additional 20 MW to the grid (SLR 2010). Approximately 35 wind farms or wind turbine projects provide an additional estimated 315 MW of power (Power Advisory 2013). Together, these sources provide an approximately 2,590 MW of electricity.

As of January 2013, approximately 130 MW of community-based renewable energy projects have been approved as part of the COMFIT program. In 2012, 116 MW of new medium- and large-scale wind energy projects led by Independent Power Producers were procured through a competitive process by the independent Renewable Electricity Administrator. In September 2012, the federal government passed a regulation requiring coal plants to shut down at the end of their 50 year life, making the need to move away from coal to alternative energy sources even more urgent.

2.11.2 Future Energy Mix, Transmission and Distribution Capacity

The 2013 renewable electricity standard requires 10% of NSPI electricity to come from clean renewable resources. Currently, approximately 18% of Nova Scotia's electricity originates from renewables and so this target has been exceeded. The 25% target by 2015 would more than double the renewable electricity proportion from 2009 levels. Achieving the 40% requirement by 2020 may require additional or upgraded grid connections with other provinces, and an expanded role for imported hydroelectric power (Power Advisory 2013). Increased capacity will be needed to deliver the new renewable electricity generated, while transmission system investments will be required to manage the intermittent nature of many sources of renewable energy (NSDOE 2010).

Wind power will be the primary resource used to reach the 2015 renewable energy commitment of 25%, along with existing local hydro and limited amounts of other renewable resources, mainly biomass (Power Advisory 2013).

Most of the new renewable energy needed to meet both 2015 and 2020 commitments will come from large-scale projects. The *Renewable Electricity Plan* expected the need for 600 GWh of energy from larger-scale projects to meet the 2015 target. However, with lower power demand following recent paper mill closures and due to other factors, this number is now expected to be lower. This amount of additional electricity contracted to Independent Power Producers in 2012 is now expected to be sufficient to meet the legal requirements for additional renewable electricity by 2015 (Power Advisory 2013).

The goal of 40% renewable electricity supply by 2020 is a legislative commitment in the *Electricity Act* and the amended *Environmental Goals and Sustainable Prosperity Act* (2012). After 2015, Nova Scotia committed to consider several alternatives to achieve the 40% renewable electricity supply including: (1) more intermittent sources such as wind and tidal, complemented by natural gas; (2) stable renewable energy sources such as biomass and hydroelectric energy from Lower Churchill; and (3) more clean energy imported from other neighbouring provinces (Power Advisory 2013).

Hatch (2008) was requested by NSDOE to assess the impacts of adding large amounts of land-based wind-generated electricity to the electrical grid. To a certain extent, their findings apply to other renewable energy sources, such as tidal, wave and offshore wind, at least with respect to limitations of the existing grid system. Integrating intermittent renewable energy into the grid requires balancing a number of priorities and costs related to other system components (SNC Lavalin 2009).

As noted by Hatch (2008):

> "All components of the delivery system will experience greater load variations. The system may be called on to operate in ways it was not designed for and the total cost impacts are not well understood at this time. There could be significant infrastructure costs involved ($100s of millions) to upgrade Nova Scotia's transmission system to integrate these levels of wind. Costs will also depend greatly on how the system evolves in the next several years, particularly Nova Scotia's interconnections to neighbouring regions."

Hatch 2008 went on to conclude that more detailed system impact studies are required to assess the different variables that affect transmission system operation and cost. They identified the following factors as key influencers of cost and grid stability:

- Location of new projects;
- Regional interconnections (including NB, NL, and USA);
- System upgrades;
- Back-up supply issues; and,
- Technological innovation.

Building on the 2008 Nova Scotia Wind Integration Study, NSPI (2013) identified the key investments that would need to be evaluated in order to integrate additional large - scale wind power (and by extension, tidal power) into the existing electrical system. NSPI (2013) concludes that

> "...there are operational and planning related challenges associated with the integration of the large levels of variable renewable generation that would be necessary to achieve compliance in 2020. Most of these challenges can be addressed and mitigated, but require appropriate (and sometimes substantial) investments in the power system as well as significant shifts in operating practices. The variable nature of wind, together with other dispatch challenges, make the high wind option dependent on natural gas and energy imports. Investments in fast acting generation, stronger interties, load shifting, and load management will be necessary to allow the system to be operated reliably. NSPI is in the process of completing its renewable energy integration study to allow a more complete understanding of the operational impacts of integrating substantial amounts of wind generation into the power system."

2.11.3 Power Transfer, Integration, and System Stability

The Nova Scotia transmission system has three major interfaces, each with power transmission limitations dictated by the design of the transmission lines and supporting facilities: the Cape Breton Export interface, where power is transferred from the generating stations in Cape Breton to the urban consumers of mainland Nova Scotia; the Onslow Import transfer interface, where power is transmitted and received from New Brunswick and is moved east-west across the province; and the Onslow South transfer interface, where power is shunted to the southwestern portion of the province. The existing upper and lower power transfer limits on these interfaces have been determined by NSPI through dynamic stability studies. If any of these interface flows approach the set limits, a series of measures must be taken to maintain system stability and to ensure that no thermal loading or violation of voltage limits will occur (SNC 2009). Depending on system conditions, these transfers have to meet the following ranges:

- Cape Breton (CB) Export Transfer Interfaces (600 MW - 900 MW);
- Onslow Import Transfer Interfaces (900 MW - 1050 MW); and,
- Onslow South Transfer Interfaces (500 MW -900 MW).

Nova Scotia transmission interface constraints are shown in Figure 2. The arrows on the figure represent the incremental power flow across the interfaces from renewable energy projects awarded prior to 2009.

As noted, the variable nature of certain types of renewable energy (such as wind and tidal) is a concern for both system operators who must predict the minute-to-minute output of power producers in order to manage the system load, and for power producers who participate in day-ahead markets[5]. Typically, power producers are required to provide power in accordance with the amount and time they have scheduled with the system operator, otherwise they incur penalty fees. Without proper forecasting tools, it is difficult for power producers to participate in day-ahead markets. Even with wind forecasting tools, some error between actual and forecasted generation is inevitable. The more predictable nature of tidal forecasts makes tidal energy an easier power source to integrate into the provincial grid than wind, although both sources are inherently variable in nature (M. Sampson, pers. comm. 2013).

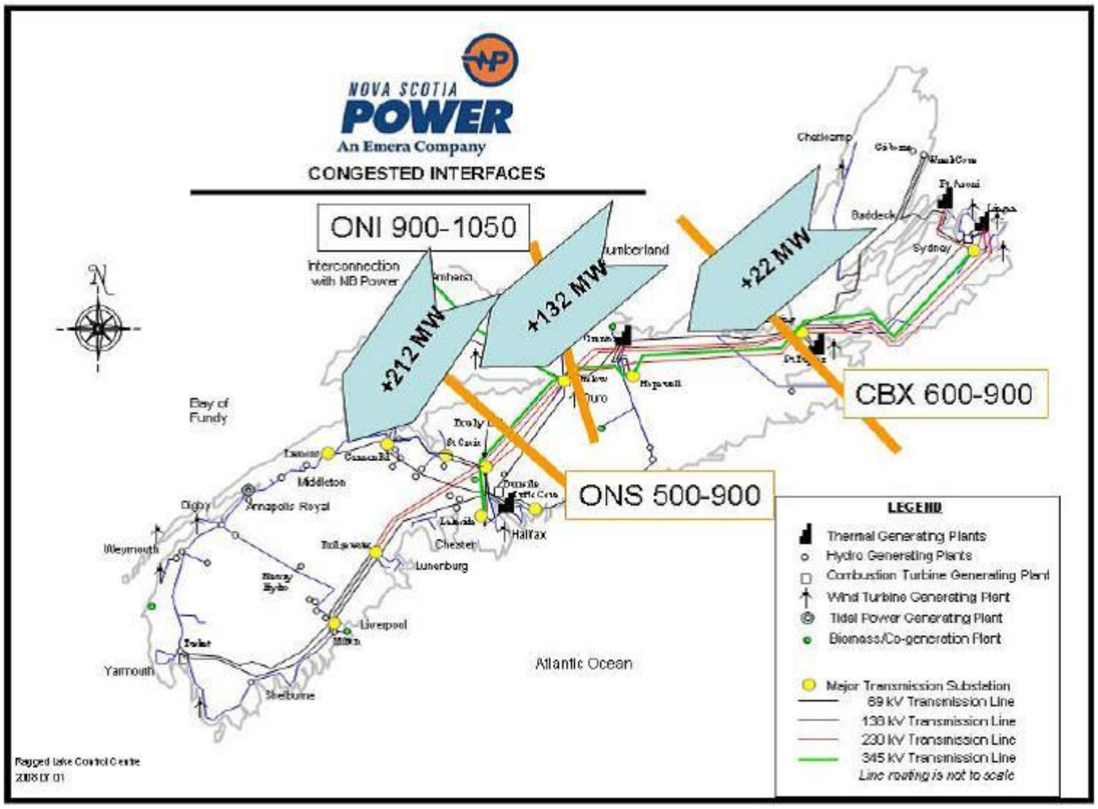
The system operator can avoid overloading the system and triggering a collapse or moving energy out of the province, by managing generation within the province. When excess energy is being generated by renewable energy projects, some traditional generation capacity can be removed from the grid or the generators can be shut down. This is not possible for all types of generators (e.g., nuclear), and may be damaging to other types, including some of the equipment operated by NSPI. Another way the system operator can manage the system load is through energy storage solutions (e.g., batteries, compressed air, flywheels, capacitors, hydrogen, thermal or pumped storage for hydro), however, these again come with associated costs that must be added to the sale price of electricity (M. Sampson, pers. comm. 2013).

Historically, electricity generation by conventional coal, natural gas, and hydroelectric plants has been predictable, while demand or load has been variable. Currently, this model is in a transition period, as more renewable energy projects, with their variable and often unpredictable inputs are integrated into the grid. In summary, the transmission system will experience greater demands with the integration of renewable energy projects and will require transmission upgrades. The limitations identified for wind integration can be expected to apply to tidal projects. There are likely to be cost implications to the actions taken to integrate this power into the grid. These actions may include importing additional electricity (when renewables are off-line), starting and stopping thermal generation units, managing interruptible load and limiting wind and tidal generation at certain times (NSDOE 2008). Moving forward

[5] A day-ahead energy market is a financial market where people buy and sell energy at binding prices for the following day. The day-ahead market allows buyers and sellers to lock in their price and hedge against volatility in the real-time energy market.

past 2013, additional analysis is required to understand infrastructure costs (which may be significant), system stability and interconnection options to neighboring regions.

Figure 2. Nova Scotia Transmission Interface Constraints

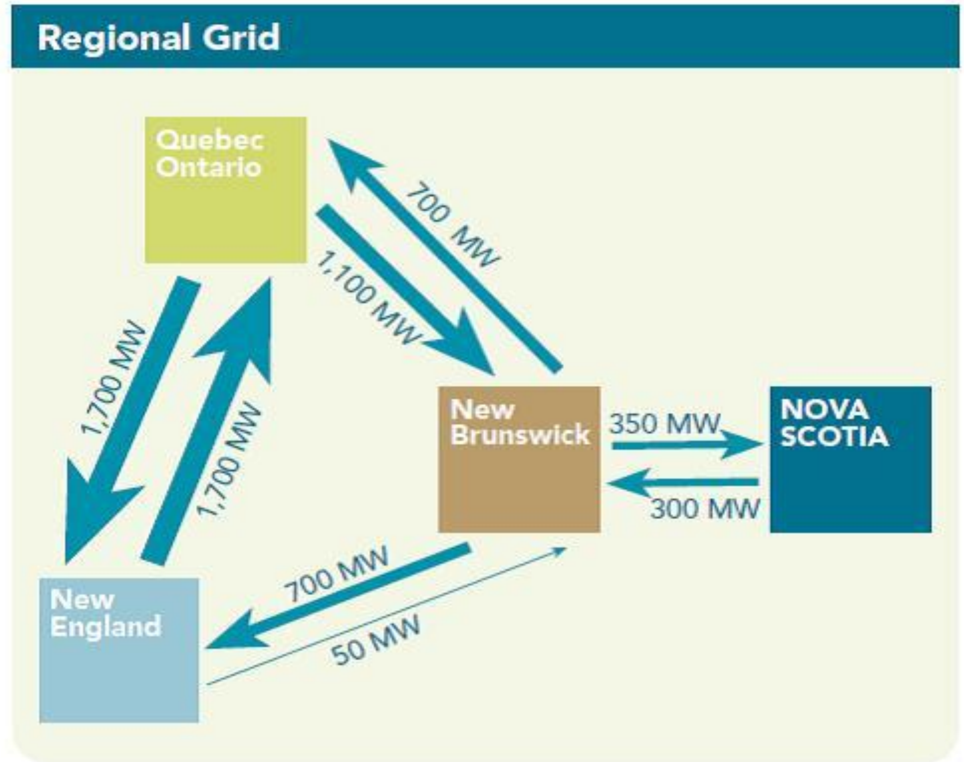


Source: Transmission and System Operator Options for Nova Scotia (SNC 2009)
Arrows represent power flow across the interfaces from renewable generation projects awarded prior to 2009

2.11.4 Regional Interconnections

In terms of regional transmission capacity, Nova Scotia is presently limited to a single 350 MW connection with neighbouring New Brunswick. This means that the province must produce nearly all of the electricity it consumes because at present, only a limited amount of electricity can be imported through the 350 MW New Brunswick connection. This is in stark contrast to other provinces in the region (Figure 3) (NSDOE 2009a).

Figure 3. Regional Energy Grid



Source: Nova Scotia's 2009 *Energy Strategy* (NSDOE 2009a)

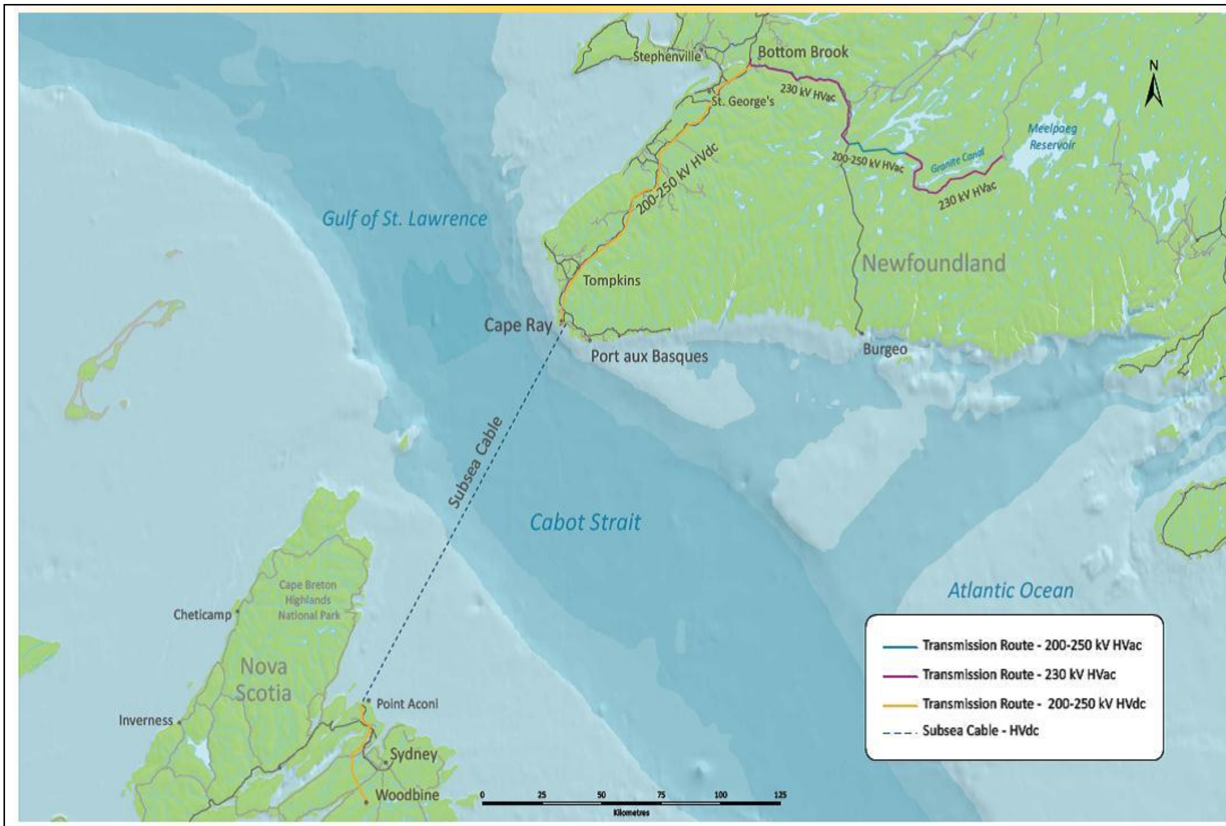
System loads, or the 700-2,200 MW of energy demanded by customers, vary throughout the day, and these loads must be met by the utility on a minute-by-minute basis. If these loads cannot be met internally through generation at that moment, then additional energy must be brought in from New Brunswick. If the internal generation is in excess of the system load at any point in time, the extra electricity must be pushed into New Brunswick so that the provincial grid is not overloaded. System response to real-time demand is managed by the system operators of each province, who predict these interprovincial transfers ahead of each day. This exchange is closely monitored and must be maintained within strict limits so that the provincial grid is not damaged, which can lead to grid collapse. Managing system load on a moment by moment basis is further complicated with the introduction of unpredictable and intermittent renewable wind energy. In contrast to wind, tidal energy is entirely predictable although it, too, is intermittent and so must be supplemented with other sources of energy.

Enhancing Nova Scotia's transmission grid by adding an interconnection with New England via submarine cable or a second interconnection to New Brunswick has been identified as a way to improve opportunities for the import and export of renewable energy (NSDOE 2010). Strengthening connections would not only enable each province to add more renewable energy to the system than it could do on its own, but allows the import and export of clean energy between regions when needed. This would create a grid that is inherently more stable and reliable. The Atlantic Energy Cooperation Initiative comprised of all four provinces is working towards this goal (NSDOE 2009a). However, expanding and creating new interconnections present challenges; a second interconnection with New Brunswick would require upgrades in both provinces, and the submarine connection with New England has significant cost implications (NSDOE 2010).

In 2010 the Nova Scotia Utility and Review Board (UARB) approved NSPI to proceed with the acquisition of a right-of-way to accommodate a second 345 kV connection with New Brunswick. However; it is becoming increasingly difficult to obtain access to the land and the rights-of-way required to undertake transmission and distribution projects. This second interconnection is estimated to take at least 5 years before permits are in place and construction is complete (NSPI 2012). It is expected that the second intertie development would cost in the range of $200-250 million, not including reinforcement on the New Brunswick side (SNC 2009).

Emera Inc. is planning to construct a high voltage direct current Maritime Transmission Link between Newfoundland and Nova Scotia to allow Nova Scotia to access renewable energy from the Lower Churchill Hydroelectric Project (Figure 4) (Nalcor Energy 2013). The Maritime Link is a proposed 500 MW system providing 900-1100 GWh of electricity annually to Nova Scotia. It will include 300 km of overland transmission in Newfoundland, two 180 km subsea cables across the Cabot Strait, and 50 km of overland transmission in Nova Scotia (Emera Newfoundland and Labrador undated). Construction was approved in December 2012 and is expected to take five years (Nalcor Energy 2013). It is expected that the development of the Maritime Link will cost in the range of $3.0-4.5 billion (SNC 2009). This construction, if built with sufficient capacity, may also be used to accommodate the growth of the renewable energy sector in Nova Scotia (Fournier 2011). The Maritime Link will provide Nova Scotia with a significant amount of renewable electricity on an annual basis (Power Advisory 2013) and is expected to provide additional opportunities to manage Nova Scotia's base load through power import and export across the Link.

Figure 4. Future Maritime Transmission Link

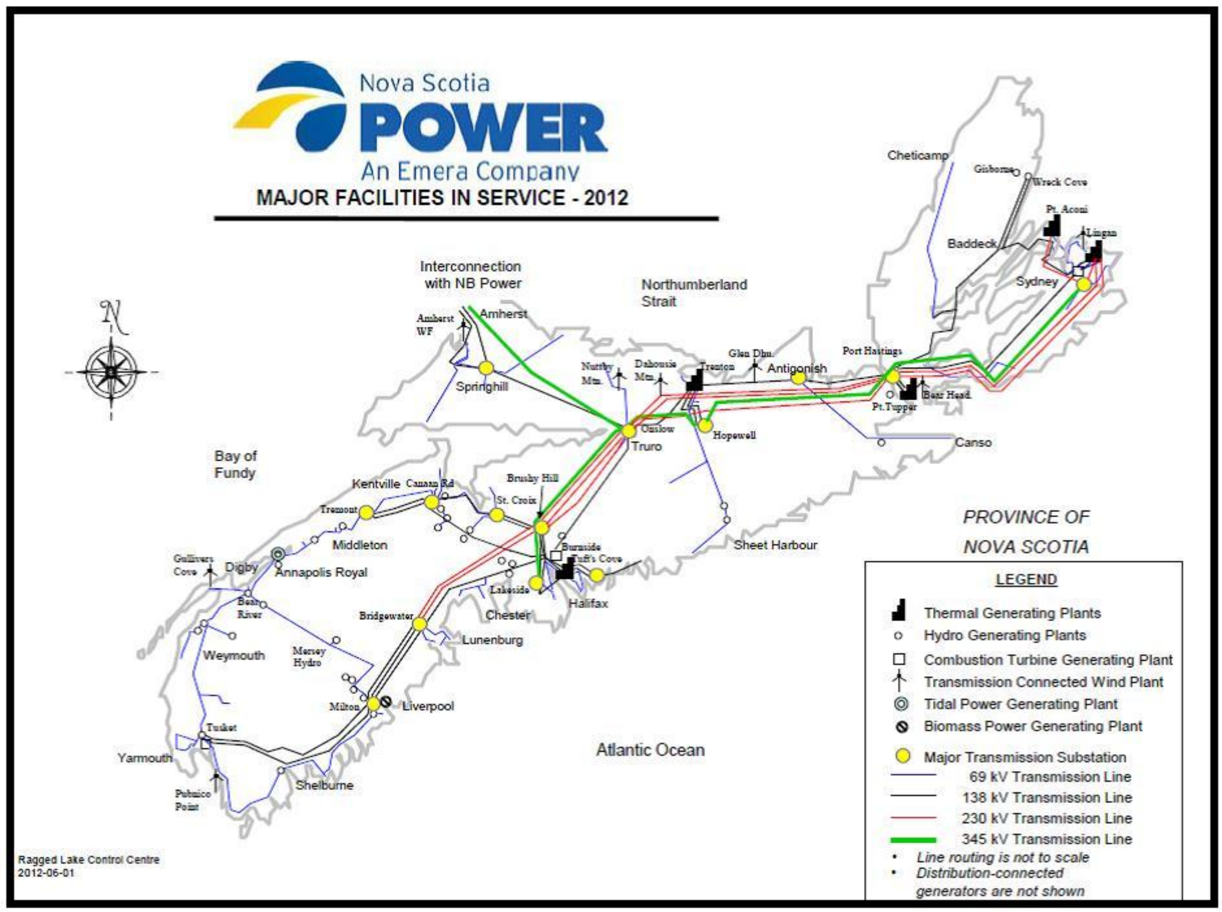


Source: Maritime Link (Nalcor Energy 2013)

2.11.5 Project Location and Interconnection

As of 2012, Nova Scotia's transmission system includes approximately 5,200 km of transmission lines at voltages of 69, 138, 230 and 345 kV (NSPI 2012a) (Figure 5). A single 345 kV transmission line runs from Woodbine near Sydney to Onslow, near Truro. From Onslow, a single 106 km long 345 kV line connects to Lakeside in the Halifax area. In parallel with the 345 kV line, two 230 kV transmission lines run from Lingan near Sydney to Port Hastings. From Port Hastings, three 230 kV circuits are connected to Brushy Hill in the Halifax area via Onslow (Hatch 2008). New lines will be required to connect widely scattered, intermittent MRE sources in remote locations (NSDOE 2009a).

Figure 5. Nova Scotia Transmission System and Major Power Facilities



Source: 10 Year System Outlook 2012-2021 Report (NSPI 2012b)

For new tidal projects, cost effective connection not only depends on the distance to the distribution grid but also on the available capacity of the grid. For small scale community projects, the cost to connect to the grid may consume a significant portion of the revenue from electricity sales. As part of the COMFIT application, a grid connection/capacity assessment is conducted by NSPI for each application. Projects over 100 kW must submit a Distribution Generator Interconnection Request. The NSPI connection/capacity assessment provides the magnitude of costs associated with any necessary upgrades to the grid.

As of June 2012, a total of 27 Active Transmission Interconnection Requests have been received by NSPI, totalling 1,103 MW. These requests are at various stages of interconnection study. Of these requests, nine are for renewable generation projects (wind and biomass) with a cumulative nameplate capacity of approximately 265 MW, although none of the projects are for tidal energy. In addition, a total of 128 Active Distribution Interconnection Requests have been received by NSPI, totalling 406 MW. Again, these requests are at various stages of interconnection study. Of these requests, renewable energy generation projects account for more than 105 MW (NSPI 2012a).

In support of the FORCE project, submarine cables with a feed-in capacity of 64 MW will be installed to connect in-stream tidal energy devices in designated berth areas to an on-shore substation. The output from the initial demonstration of tidal units in Minas Passage will not exceed 5 MW. In the spring of 2012, a 10 km long, 69 kV transmission line was also constructed in support of the project, connecting FORCE to the provincial energy grid. This transmission line is intended to service the Demonstration project, as well as any future tidal power demonstration arrays in Minas Passage.

3. Supporting Services and Economic Benefits

Section Summary

This section describes the Nova Scotia-based institutions, industries and expertise that are available to support tidal energy development, including the FORCE site and its research objectives. The section outlines the economic benefits that may be achieved as this industry develops in Nova Scotia and presents a description of how these benefits may be retained in the local and regional areas.

3.1 Overview

Substantial economic opportunities exist from the creation of a Nova Scotia-based tidal energy industry, with the greatest long-term opportunities resulting from the development of supply chains that provide infrastructure, products, and supporting services (Fournier 2011). Currently, the tidal energy industry in Nova Scotia is an emerging sector and will require significant growth to support a fully developed supply chain (ATEI 2013). The primary objective of provincial and federal investment in this industry is to enable the development of these supply chain economic opportunities, building Nova Scotia-based technical expertise in design, manufacturing, monitoring, maintenance, deployment/retrieval, and vessel support. Such expertise has the potential for export to projects elsewhere in the world.

In addition to Mi'kmaq connections to the marine environment, which are over 9,000 years old, Nova Scotia's cultural environment has ties to the ocean dating back 400 years. The result is that Nova Scotia has thousands of independent fishing vessels, dozens of boat builders, ports, shipyards, offshore energy projects and other ocean-related assets (Government of Nova Scotia undated). Nova Scotian companies are already becoming global leaders in innovative marine technologies (NSDOE 2012) and the Province is home to a skilled workforce that includes scientific, engineering and socio-economic research capacities, with approximately 300 firms currently working with ocean technologies (Fournier 2011).

3.2 Ports

There are numerous ports and harbours throughout Nova Scotia; many are deep and ice-free and some, such as Halifax and Canso have the capacity to handle some of the largest ships in the world. Nova Scotia has the closest mainland ports in Canada to South Asia, including India, and Southeast Asia via the Suez Canal. It is also a one-day sail closer to major European markets than from any other mainland North American port. Following initial experiences in other jurisdictions, it has been estimated that for every Gigawatt of tidal energy installed in Nova Scotia, three or four expanded port facilities are required (EXP Services Inc. 2013). In Nova Scotia, nearly 25 ports were identified on a preliminary basis as have facilities and strategic locations to provide an appropriate level of support to the MRE industry (Figure 6).

The Bay of Fundy's tidal variation is a significant challenge when planning new wharf infrastructure needed to support MRE (CWS 2011). For "dry ports" such as Parrsboro where the harbour bottom is exposed at low tide, it is not always practical or financially viable to extend wharfs into deeper water so that they can provide adequate depth at low tide. Tidal industry representatives have suggested that currently planned "short-term" TISEC deployments can be accommodated from existing ports such as Halifax, Hantsport (with planned enhancements), Parrsboro or other ports located between Shelburne and Digby (CWS 2011). "Short term" is defined as occupation of FORCE's four approved berths - up to 64 MW generating capacity - and up to 10MW of small tidal devices. CWS (2011) writes:

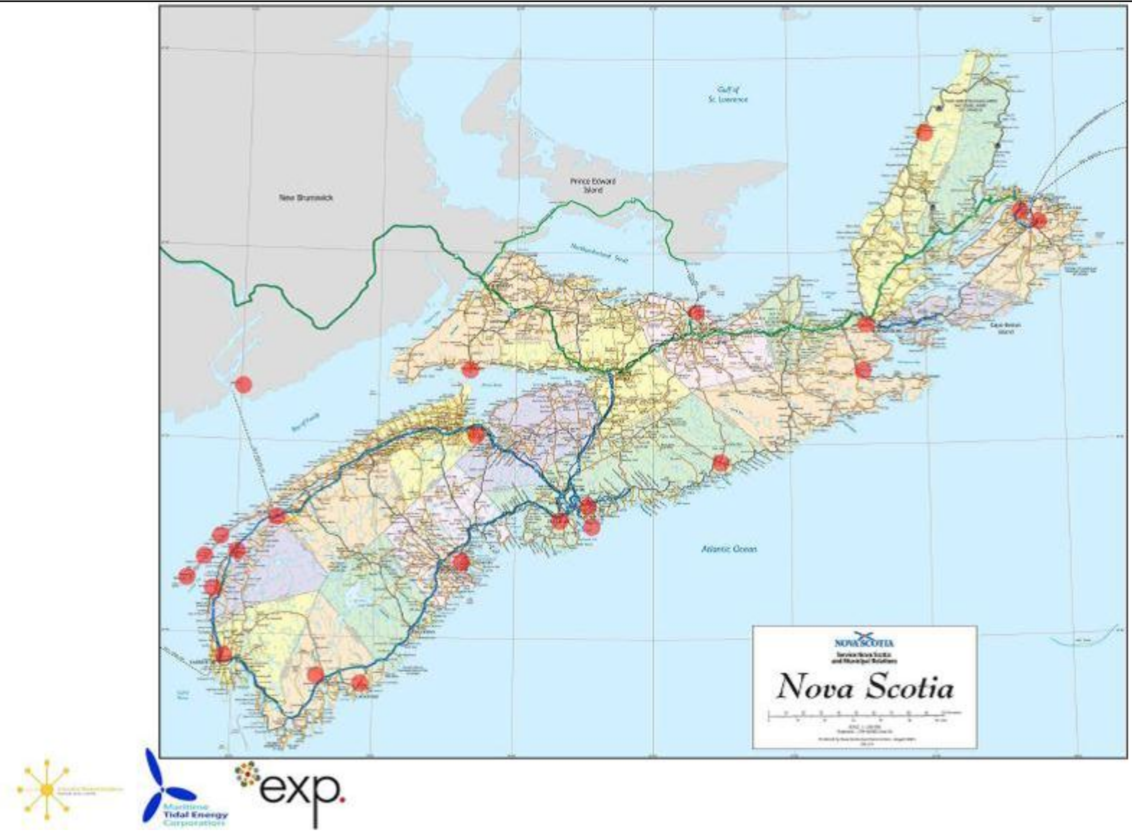
> *Some in-stream tidal power developers, particularly those using pin/pile base structures that can be designed to float, will likely devise schemes to deploy or conduct some operations from dry ports (i.e. Hantsport or Parrsboro). Ramps or floating dry docks can be constructed to enable these structures to be launched in a similar way to newly-built boats (…) To support small tidal devices in the Digby Neck area, it is expected that several ports will be suitable including Digby, Meteghan, Meteghan River, Saulnierville and Weymouth, which are close to the planned and proposed "short-term" deployment sites in Grand Passage, Petit Passage and Digby Gut. Fabrication and assembly capabilities also exist near some of these ports. It is also reasonable to expect that Freeport, Westport, Tiverton and East Sandy Cove will potentially provide a support role.*

In order to support the industry beyond the initial "short-term", deployment facilities within 150 km of project sites are needed (CWS 2011). There are two regional ports which are considered suitable for the "long-term" deployment phase: Saint John and Digby.

Digby Harbour is reportedly a suitable "wet port", well positioned geographically to deliver services to the tidal energy industry in the Bay of Fundy (Maritime Tidal Energy Corporation 2011). Although strategically located, the port does not currently have the wharf structure or land necessary to adequately support in-stream tidal power development (CWS 2011). In 2012 the Municipality of the District of Digby commissioned a site selection study for a proposed tidal technology "support base" for projects in the Bay of Fundy (EXP Services Inc. 2013). The preliminary cost estimate for the expansion of the existing Fisherman's Wharf is on the order of $21 million. The study estimates that for the construction of the support base, out-of-province materials would account for only 10% of the total cost, with the remaining expenditure ($18.9 million) constituting direct benefits to the province, the majority of which will be local/regional benefits - approximately $16.1 million. Another $13.3 million in indirect impacts for the province could also be anticipated (EXP Services Inc. 2013).

The Municipality of the District of Digby is currently in the process of defining their role in supporting the tidal energy industry. The Municipality is also trying to establish how Fundy Tidal's COMFIT approvals could be leveraged and/or shared with the Municipality to both attract project developers and offset the costs of tidal energy research and development. The Municipality is seeking opportunities to develop Digby as an incubation centre where small-scale tidal and renewable energy developers could demonstrate their technologies (T. Thibodeau, pers.comm. 2013).

Figure 6. Preliminary Shortlisted Ports to Support MRE Projects



Source: Marine Renewable Energy Infrastructure Assessment (Maritime Tidal Energy Corporation 2011)

3.3 Research Entities

The Halifax-Dartmouth area supports a world class research and ocean technology community. Universities and government laboratories have developed intellectual capacity in various areas of marine research (Fournier 2011), with 450 PhDs in ocean-related disciplines residing in Nova Scotia - the highest concentration in the world (Nova Scotia Government undated). Many of these organizations and members of the private sector participated in early tidal energy research in the Bay of Fundy, such as the 2008 Bay of Fundy SEA and the 2010 impact assessment for the FORCE Tidal Energy Demonstration project (Fournier 2011).

In addition to the Fundy Ocean Research Centre for Energy (FORCE), Canada's leading test centre for tidal energy, Nova Scotia is home to the Bedford Institute of Oceanography (BIO), Canada's largest centre for ocean research, the National Research Council Institute for Marine Biosciences (NRC-IMB), Dalhousie University's Halifax Marine Research Institute (HMRI), Acadia University's Centre for Estuarine Research (ACER) and recently established Acadia Tidal Energy Institute (ATEI), and the Centre for Marine Research at Université Sainte-Anne. At a national level, Marine Renewables Canada advocates on behalf of offshore wind, wave and tidal energy across Canada, sponsoring events, conferences and meetings with government and academia.

NSDOE works with academic institutions as well as industry, not only to build capacities in science and engineering, but also to address common issues associated with industry development (NSDOE 2012). The province is committed to working with its universities and colleges to monitor emerging skill requirements to alleviate current and future skill shortages in the MRE industry (NSDOE 2009b).

The 2008 SEA recommended the establishment of a Fundy Tidal Energy Research Committee to coordinate efforts to address the technical and environmental challenges of MRE development. To this end, the Fundy Energy Research Network (FERN; http://fern.acadiau.ca) was created in 2010 as a regional research network to address environmental, technical and socio-economic issues of tidal power projects specifically in the Bay of Fundy. FERN is an independent and impartial, not-for-profit organization with regional, national and international members spanning universities, federal and provincial agencies, environmental non-government organizations, consultants, and private sector interests.

3.4 Fundy Ocean Research Centre for Energy (FORCE)

The joint federal-provincial Environmental Assessment for the Fundy Tidal Energy Demonstration project began in 2008 upon completion of the Phase I SEA for the Bay of Fundy. The project, now managed by FORCE, consists of four subsea berths, a substation, and a visitors center near Black Rock approximately 10 km southwest of Parrsboro, NS. The environmental assessment process was successfully completed in late 2009 and the first turbine was deployed soon after.

FORCE was established to act as a hub of tidal power research. Its objective is to promote innovation and development of the tidal energy industry by providing common facilities to lower the barriers to experimentation, demonstration, monitoring and analysis of tidal energy. The site is used to demonstrate and test pre-commercial tidal energy conversion devices for the purpose of making improvements and reducing the cost of producing energy (NSDOE 2012). The establishment of the demonstration facility provides Nova Scotia with the opportunity to gain an advantage in the international marketplace by providing tidal energy device test facilities, thereby allowing for the early identification of the best technologies and the development of supply and support capabilities for the future market (SLR 2010). FORCE also collaborates with developers, researchers and regulators to study the interactions between tidal turbines and the environment.

Three technologies have been selected by the Province for demonstration, while a fourth berth is currently vacant. A request for proposals to occupy the fourth berth has been issued by the Province. OpenHydro vacated its' berth in 2011. The selected technologies are:

- Siemens-owned Marine Current Turbines (partnered with Minas Energy), which has deployed a device in Strangford Lough, Northern Ireland;
- Tidal Generation Limited (partnered with Alstom), which has a 1 MW device at EMEC; and,
- Atlantis Resource Corporation (with Lockheed Martin and Irving Shipbuilding), which also has a device at EMEC.

OpenHydro with NSPI tested a 1.0 MW turbine at the FORCE site between November 2009 and December 2010. The OpenHydro unit experienced technical problems shortly after deployment and was removed from the water in late 2010. Despite the technical problems, the complex deployment and retrieval process undertaken using a custom designed barge was a reported success, and much was learned regarding operating windows in a high energy tidal environment, multiple tug deployment, logistics and planning during the process. The NSPI/OpenHydro experience also showed that not only is there significant energy in the Bay of Fundy, but that this energy can be extracted by tidal turbines (M. Nadeau, pers. comm. 2013). A report on the deployment and recovery operations is posted on the FORCE website and is available here.

Four subsea cables have been purchased for installation at the FORCE site. Each cable can accommodate up to 16 MW of electricity, which means that more than one device can be deployed in each of the four berths[6]. This "array option" allows a company demonstrating its technology to deploy small groups of turbines to evaluate a variety of commercial and technological questions not faced by single units. These questions include, for example, the design and use of subsea connection hubs, array spacing and device interference, cumulative environmental effects, etc. Although the FORCE site does not currently host a TISEC, tidal devices are expected to be deployed at the site in 2015, following subsea cable installation in 2013-2014.

3.5 Supply Chain Economic Benefits

At the present time, the MRE industry is without a dedicated supply chain. Tidal energy developers must rely on the services of companies that are currently serving other larger, more lucrative industries (e.g., oil and gas, shipbuilding, manufacturing, wind energy). Similarly, skilled workers required to support the MRE industry are currently employed by these competing businesses. One of the challenges for the MRE industry is to make advances that reduce capital costs in the absence of dedicated supply chain companies. These companies, as well as developers, lenders and investors, require some level of assurance that tidal energy is likely to be profitable over time. The capital and operating costs and methods for evaluating the financial viability of the capital investment and the initial cost of energy are presented in the Business and Community Tidal Energy Toolkit (ATEI 2013).

Economic benefits resulting from the development of tidal energy in Nova Scotia may include:

- Direct employment, including use of local content and contractors;
- Indirect employment opportunities resulting from an influx of workers into a community;
- Offseason employment for seasonal workers including skills to help the transition from traditional to emerging marine industries;
- Development of education and training programs (expansion of current programs or creation of new ones to support industry demands);
- Land rental or lease fees;
- Revenue or payment to the community for community owned projects;
- Tourism and recreation opportunities;
- Long-term stability of energy prices (contingent on continued political will to provide renewable energy process access to markets); and,
- Research and development opportunities.
  (source: ATEI 2013).

An overview of Canada's early stage MRE supply chain opportunities identified both weaknesses and strengths (NRCan CanmetENERGY 2011). The country's strengths include: deep sea ports, marine construction expertise, resource monitoring and analysis, environmental assessment, marine supplies, commercial diving and transport. Areas of weakness include: device manufacturing, engineering construction and foundations/anchoring experience. These subject areas are described in more detail in Stantec 2011a, NSDOE 2011, and Gereffi *et al.* 2012.

There are similarities between tidal energy systems and other offshore infrastructure in terms of materials, offshore operations and electrical cables. These similarities allow marine support services that are accustomed to serving the offshore energy and offshore construction industries to provide certain common services to the tidal industry (NSDOE 2011). However, a challenge to the manufacturing of tidal devices is that they vary widely in design, such that component parts are particular to a single design, reducing economy-of-scale benefits. In addition, companies

[6] *The FORCE site is currently authorized to host up to four turbines with a combined total output of 5MW. Proposed arrays generating more than 5 MW would require project-specific environmental assessment and additional operating permits before any TISECs were deployed.*

that invest heavily in R&D may be reluctant or unable to have parts manufactured elsewhere, consequently lowering the potential for manufacturing jobs where the devices are eventually deployed (NRCan Canmet 2011).

In general, easy access to service ports and the availability of skilled service personnel with appropriate equipment are essential for the effective development of the marine energy industry (Carbon Trust 2011; Drake 2012). While port access is a necessary feature, so too is the availability of vessels with the capacity to carry the equipment and loads required to install and service MRE devices. A variety of vessels is required for the MRE industry including dynamic positioning vessels, remotely operated vehicles, barges with large cranes capable of lifting up to 400 tonnes, catamaran barges, tugs, and smaller vessels. Larger vessels may also be needed, such as jack-up barges and purpose-built offshore installation vessels. Many of these vessels also serve the offshore oil and gas industry. The availability of these specialist vessels is limited and they can be costly; however, the long range benefits to a region from construction is dependent on the consistency of contracts, the availability of skills and experience, and the ability to develop skills and experience that can be exported (Drake 2012).

3.6 Local and Regional Economic Benefits

Supply chain opportunities for multi-unit tidal arrays include manufacturing, servicing, maintenance, and monitoring. It has been estimated that the deployment of just 55 tidal turbines with 2 MW ratings by 2020 has the potential to create 340 person-years of employment, amounting to approximately $165 million (SLR 2010). Service and maintenance over the life-span of the tidal turbines could add another 550 person-years and benefits in the order of $30 million (SLR 2010). The development cost for an in-stream tidal energy device is projected at approximately $10 million per MW of nameplate capacity installed – five to ten times the cost of on-shore wind (ATEI 2013).

The potential economic impacts resulting from the development of a 5 MW tidal facility in the Digby area have been estimated by ATEI (2013). For the purposes of the estimate, it was assumed that 70% of the capital and service costs would go to local firms. The total economic impact (direct/indirect/induced) on spending across all industries in Digby County from the development/construction phase of the project is estimated to be approximately $46 million, with total income creation of $14.3 million. This would be expected to generate 240 person-years of employment. Expenditure impacts associated with the project would be concentrated in the construction and manufacturing industries, with spending in the order of $13.7 million and $13.1 million, respectively. The annual operational phase expenditures are anticipated to be much smaller in magnitude, but are ongoing throughout the life of the project. These expenditures are expected to be $344,000 per year, with an annual income creation of $124,000 or the equivalent of two well paid, full-time jobs.

Valuable lessons can be learned from commercial scale projects located elsewhere. In Orkney (Scotland), a plan to install 1,000 MW of marine renewable energy by 2020 is currently underway. The plan includes three or four new ports, two or three assembly and maintenance yards, 20-30 maintenance boats, several large purpose-built vessels, a major electricity grid upgrade and a local workforce of 500-1000 people.

In Maine, Ocean Renewable Power Company (ORPC) states that 100 jobs have been created or retained to date. ORPC estimates the tidal energy industry will attract $1.0 billion dollars in investment and create an additional 400 to 500 jobs over the next seven to ten years (Stantec 2011a). Power generated from ORPC's Cobscook Bay Tidal Energy Project will be enough to power 75 to 100 homes. Future expansion plans will provide 5 MW of power, enough energy to supply power to over 1,200 homes and businesses in Maine (Colton 2013).

3.7 Strategies to Retain Economic Benefits from Tidal Development

Several studies have focused on strategies to promote and retain socio-economic benefits (Drake 2012; Howell and Drake 2012; ATEI 2013). The promotion and retention of positive socio-economic impacts resulting from commercial scale tidal development is encouraged at the provincial scale through collaboration and cooperation to foster industry clusters where groups of related companies and organizations can combine to produce efficiencies (ATEI 2013). A dynamic business-focused cluster is currently being developed through:

- A formal industry association (Marine Renewables Canada) which provides supplier information sessions/networking events to inform suppliers of potential opportunities, educate them on the goods and services required by the MRE industry and enable them to showcase their expertise and capabilities;
- Building on previous events and established networks to further inform suppliers and discuss how best to address identified gaps. These events and networks include Fundy Energy Research Network (FERN), conferences, Commercialization Workshops, NS Tidal Energy Symposiums, OERA/FORCE/DFO sponsored Research and Development Workshops and university events such as Dalhousie's Oceans Week;
- Aligning infrastructure and supply chain requirements to develop the marine renewable energy sector with economic development and sector development agencies and initiatives; and,
- Collaboration with adjacent jurisdictions to identify shared interests and opportunities (Drake 2012).

Community support for and retention of socio-economic benefits from tidal energy projects are linked to the community's level of investment in the project: community ownership vs. shared ownership vs. developer as owner. Each level of community involvement will have different potential benefits for the community (ATEI 2013). Potential benefits from *community ownership* of MRE projects include local income, local control over siting issues and a higher level of environmental accountability (Howell and Drake 2012). However, full community ownership exposes the community to financial and other risks if the project fails (Halcrow Group Ltd 2009). *Developer as owner* limits the community benefits to 'spin-offs' such as increases in traffic for existing business and services. Developer ownership places the financial risk of the project outside the community, but also limits the community's role with respect to the local marine resources affected by the project (ATEI 2013).

Community benefits outside of ownership benefits will be primarily related to employment and increase demand for local services. Due to the need for technical expertise in the development and construction of tidal energy projects, the majority of the workforce will likely come from centers outside the local communities. However, several employment opportunities are outlined in ATEI (2013) and include:

- Support during research and development;
- Labour during construction;
- On-going monitoring;
- Use of local vessels; and,
- Increase in services.

The duration of these impacts will be concentrated during the development and construction stages with some residual economic impacts during the operations through monitoring and maintenance. Indirect impacts on the community scale could include improvement of infrastructure, in-kind support, provision of local services and capacity building (ATEI 2013).

4. Tidal Energy Technology

Section Summary

This section describes the current state of tidal energy technology compared to the industry described in the 2008 SEA. The most advanced in-stream tidal energy technology types are shown, along with tidal lagoon concept installations that have been suggested for the Bay of Fundy. Finally, this section lists the operating requirements for typical tidal energy devices.

4.1 The International Marine Renewable Energy Industry

The global marine renewable energy industry has evolved considerably since the Phase I SEA for the Bay of Fundy was completed in 2008. There are more technically viable prototypes and demonstration-phase tidal energy converters than in 2008, while certain leading technologies have advanced through additional testing and grid connection. Although offshore wind turbines have been deployed in commercial array configurations for over a decade, the first fully functioning tidal array resulted from the Phase III build out of the Roosevelt Island Tidal Energy (RITE) Project, installed in New York City's East River in 2006 (Walsh 2008). When complete, Verdant Energy's 1.0 MW pilot project will consist of an array of up to thirty Generation 5 tidal turbines.

The UK continues to lead the world in deployment and testing of tidal energy converters. As of March 2011, the UK had an installed grid-connected capacity of 2.05 MW of tidal energy (Renewable UK 2011). The European Marine Energy Centre (EMEC) was established in Orkney in 2003 to test both wave and tidal energy technology and quickly became the centre of a vibrant technological research and development industry in the UK (Renewable UK 2011). EMEC has eight demonstration berths. As of April 2013, tidal technologies being tested at EMEC include:

- Tidal Generation Limited (acquired by Alstom in 2013) – recently installed a generator for a 1 MW device;
- OpenHydro (an Irish company, majority owned by the French shipbuilder DCNS) – EMEC's first tidal customer (2007) and past resident at FORCE (2010), now preparing to install the seventh generation turbine at EMEC;
- Andritz Hydro Hammerfest in collaboration with Scottish Power – recently grid-connected a 1 MW device;
- Scotrenewables Tidal Power – designed, developed and deployed a floating tidal machine;
- Voith – a previous EMEC guest, preparing to test 1 MW turbine test system mounted on to a monopole drilled into the seabed;
- Bluewater Energy Services – preparing to test a tidal turbine installation and maintenance system; and,
- Kawasaki Heavy Industries – scheduled to deploy a turbine at the Fall of Warness tidal test site.
  (source: Deign 2013)

Elsewhere, Marine Current Turbines (MCT) deployed a SeaFlow unit off the coast of Devon in 2003, while Pulse Tidal deployed its Pulse Stream 100 kW generator in the Humber River Estuary in 2009 (Renewable UK 2011). At Strangford Lough in Northern Ireland, MCT is now evaluating the performance of its 1.2 MW SeaGen design, and Pulse Tidal has secured a site at the South West Marine Energy Park in Lynmouth to commercially demonstrate a 1.2 MW unit (Deign 2013).

During 2010, the Crown Estate (a property consortium owned by the UK Crown) announced the award of development rights to a number of companies for eleven wave and tidal energy projects in the Pentland Firth and Orkney waters, with a total potential capacity of 1,600 MW. The Pentland Firth and Orkney MRE projects, the largest planned development of wave and stream energy in the world, are predicted to be operating by 2020 (BVG Associates 2011).

In 2008, Électricité de France (EDF) announced its decision to build a tidal energy demonstration facility in Paimpol-Br´ehat. EDF appointed OpenHydro to develop and build the facility (Pham and Martin 2009). The first 2 MW Open Hydro device was installed at the Paimpol-Br´ehat site in August, 2011. This demonstration facility has been referred to as the world's first large-scale, grid-connected tidal energy farm and France's first offshore tidal installation (HydroWorld 2011).

In the USA, ORPC deployed its TidGen unit in Cobscook Bay near the border between Maine and New Brunswick in July 2012. This small scale unit is the first grid connected, commercial tidal project in North America and will generate up to 180 kW of electricity.

New Zealand has committed to developing three, government-funded MRE projects as part of their Marine Energy Deployment Fund initiative. The proposed MRE projects include a wave energy device at Stewart Island, turbines to generate electricity for Parnell Baths in Auckland, and a cable linking a wave energy device at Moa Point in Wellington. The government's commitment to developing renewable energy resources was underlined in the New Zealand Energy Strategy 2011-2021 Report, which includes a target of 90% electricity generation from renewable resources by 2025 (Minister of Economic Development 2011).

Through the International Energy Agency – Ocean Energy Systems (IEA-OES) group, an agreement has been reached by which guidelines for the testing of ocean energy systems will be introduced. In 2009, EMEC produced 13 Draft Standards for the Marine Renewable Energy Industry, including device performance standards, wave and tidal resource assessment standards and guidelines for project development. The goal of this independent, co-operative work is to issue through the International Electrotechnical Commission (who established the Technical Committee 114, Marine Energy – Wave and Tidal Energy Converters) a collection of international best practice guidelines and recommended procedures that will become standards for the industry.

The full potential commercial expansion of the MRE industry is expected to be realized in 2020 and onwards, when utility scale international energy projects and advanced manufacturing capabilities are produced, following significant growth over the next ten years. The Carbon Trust, an independent UK carbon reduction organization, has estimated that if the UK can maintain its position at the centre of the industry, the marine energy sector could be worth over £70 billion to the UK economy by 2050 and create tens of thousands of jobs (Regen SW 2012).

Benchmark costs for first generation marine energy farms at typical UK sites were found to be CAN$0.45-$0.52/kWh for tidal stream energy. The Marine Energy Accelerator Report suggests that with sufficient efforts focused on innovation, the costs of tidal energy could be reduced to approximately CAN$0.25/kWh by the time the Pentland Firth and Orkney Waters licensed sites are half way through development (Carbon Trust 2011).

Another indication of the growth and momentum of the MRE industry is the number of government-supported research, test or demonstration facilities around the world. These include:

- The European Marine Energy Centre (EMEC) in Orkney, northern Scotland;
- The National Renewable Energy Centre/New and Renewable Energy Centre (NAREC) in northeast England;
- Wave Hub (a grid-connected wave device testing facility) in southwest England;
- The Southwest Marine Energy Park in Bristol, Cornwall and Plymouth, UK;
- The Marine Institute in Galway, Ireland;
- The Wave Energy Centre (WaveEc) in Portugal;
- Nissum Bredning wave plant test site in western Limfjord, Denmark;
- The Northwest National Marine Renewable Energy Centre at the University of Oregon in Portland, USA;
- The Hawai'i National Marine Renewable Energy Centre;
- The Florida Atlantic University Centre for Ocean Technology in Dania Beach, Florida;

- The New England Marine Renewable Energy Center (MREC) based in Massachusetts, USA; and,
- The Fundy Ocean Research Centre for Energy (FORCE) near Parrsboro, Nova Scotia.
  (source: Mueller et al. 2010)

4.2 Principal Tidal Technology Types

Given the varied marine environments available in the Bay of Fundy, several different tidal technologies may be applicable in this region. This section describes the main characteristics of the most advanced technologies in two categories:

- Tidal lagoons; and,
- Tidal in-stream energy conversion (TISEC).

4.2.1 Tidal Lagoons

Technology Description

Over the last 100 years, tidal power development has been primarily concerned with technology utilizing the *tidal range*: i.e. conversion of the *potential* energy of water stored behind a barrier rather than the *kinetic* energy of flowing tidal waters. Assessments of the environmental impacts of barrages (a dam constructed across an estuary or across the entrance to a bay) in the Bay of Fundy have been carried out a number of times since the first proposal in 1912. In all assessments, concerns have been raised about a wide variety of effects caused by the dam itself as well as those of the turbines (e.g. Daborn 1977; Gordon and Dadswell 1984; Dadswell *et al.* 1986; Daborn 1987; Campbell *et al.* 1992; Daborn and Redden 2009). Principal concerns relate to:

- The effects of passage through the turbines on fish (and possibly mammals);
- The changes in tidal phenomena (tidal range, currents, timing, etc.) that might occur over the whole of the Bay of Fundy/Gulf of Maine ecosystem;
- The effects on sediments and associated ecological consequences as well as the potential for accumulation behind the barrage that might affect storage capacity of the reservoir; and,
- A wide variety of secondary effects associated with sediment deposition and resuspension, nutrient enrichment, contaminants, and biological productivity.

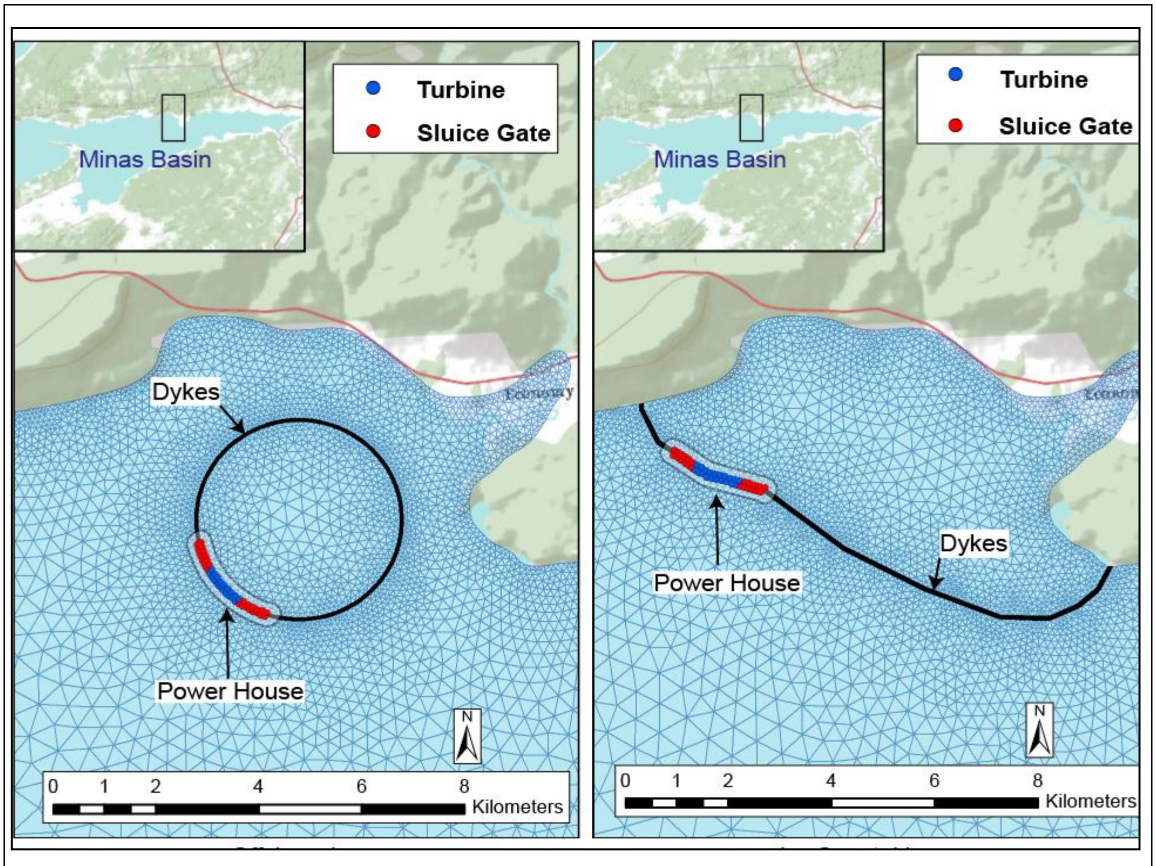
As a consequence of these concerns, tidal range energy conversion has been less popular in recent decades. Nonetheless, interest in tidal range approaches remains because of the large energy yields that such developments offer, the potentially long term operation of a tidal power barrage (which may mitigate the considerable capital investment required at the beginning), and the anticipated durability of the turbines based upon experience at the two existing tidal power stations: La Rance (France; est. 1966) and Annapolis Royal (Nova Scotia: opened 1984).

Two models based upon tidal range energy extraction have been proposed for the Bay of Fundy. Tidal Electric Canada LLC has suggested building one or more **tidal lagoons** in Minas Basin in the Upper Bay of Fundy. A tidal lagoon is an impoundment, constructed either of concrete caissons or a rubble-mound dyke, which is filled with water by the rising tide and drained on the falling tide by allowing the water to exit through the turbines. Two modes of operation are possible: a *single effect* mode, in which the turbines are only used to generate power on the falling tide (i.e., tidal flows that fill the lagoon on the rising tide are not used to generate power), and a *double effect* mode, in which the turbines are used for electricity generation on both the rising and falling tide. Power output and economic factors generally favour the single effect mode.

Two tidal lagoon concepts have been examined:

- An offshore lagoon comprising a power station and a 12 km^2 circular impoundment enclosed by an 11.9 km long dyke detached from the shore; the lagoon would contain fourteen 7.5 m diameter bulb turbines with generating capacity of 124 MW; and,
- A coastal lagoon comprising a power station and a 24 km^2 impoundment formed between a 10.2 km long dyke and the existing shoreline; this lagoon would house twenty four 20 MW turbines and have a generating capacity of 220 MW (Cornett *et al.* 2011; cf. Figure 7).

Figure 7. Lagoon Concepts for Minas Basin, Bay of Fundy



(Source: Cornett *et al.* 2011)

The second model, presented by Halcyon Marine Hydroelectric LLC, involves an impoundment across Scots Bay, near the entrance to Minas Basin (Halcyon 2012). The proposal is for a shore-connected tidal lagoon formed by a 10 km long concrete and steel barrier that would enclose about 39 km^2. Thirty eight concrete caissons containing eight 3.2 m diameter bulb turbines each, and rated at 3.62 MW each, would have a combined generation capacity of approximately 1100 MW. Although similar in many ways to other lagoon proposals, the Halcyon approach is significantly different in two respects:

- In order to preserve the pre-existing tidal range in the impoundment behind the barrier, it is proposed to use active pumping both at the end of the rising tide and at the end of the falling tide to maintain intertidal exposure; and,

- Construction using steel and concrete enables the barrier to be constructed in deeper water (yielding much more potential energy), and to be removed more readily than would be the case with a rubble-mound dyke.

The hydrodynamic effects of the proposed Scots Bay impoundment have not yet been examined (the Cornett *et al.* 2011 study considered only impoundments in Minas Basin or Chignecto Bay), but existing models would enable that to be done.

The ecological implications of these lagoon proposals have not been extensively explored as yet. However, experience with the building of tidal barriers in the past (e.g. the Annapolis, Avon and Petitcodiac causeways), and the extensive studies related to barrage-based tidal power proposals in the 1970s provide a basis for identifying potential effects that might be of concern. These can be summarized as:

- Risks to mammals, fish and other wildlife: although lagoons do not cross the estuary completely, and would therefore not inevitably impede access for migratory species moving between fresh and sea water, filling of the lagoon would likely result in fish and mammals becoming trapped inside with potentially harmful effects if they exit through the turbines;
- Local effects on sediments: for lagoons in the turbid portions of the Upper Bay of Fundy, filling the impoundment with sediment-laden water and holding the water until generation begins, will potentially allow sediment deposition in the lagoon, eventually reducing its volume, or requiring remediation measures;
- Changes to the tidal regime of the Bay of Fundy/Gulf of Maine system have numerous environmental implications even over long distances. These include: potential effects on mixing processes and associated biological productivity; consequent effects on fisheries and aquaculture; potential effects on shoreline stability, access to harbours, etc.; and fate and distribution of nutrients and contaminants;
- Supply of materials (e.g. aggregate and other rock, concrete, steel etc.) needed for construction, especially where they may be obtained from land-based sources;
- Potential implications for transportation, harbour facilities, recreation and tourism, etc.; and,
- Capital investments and long term return on investment.

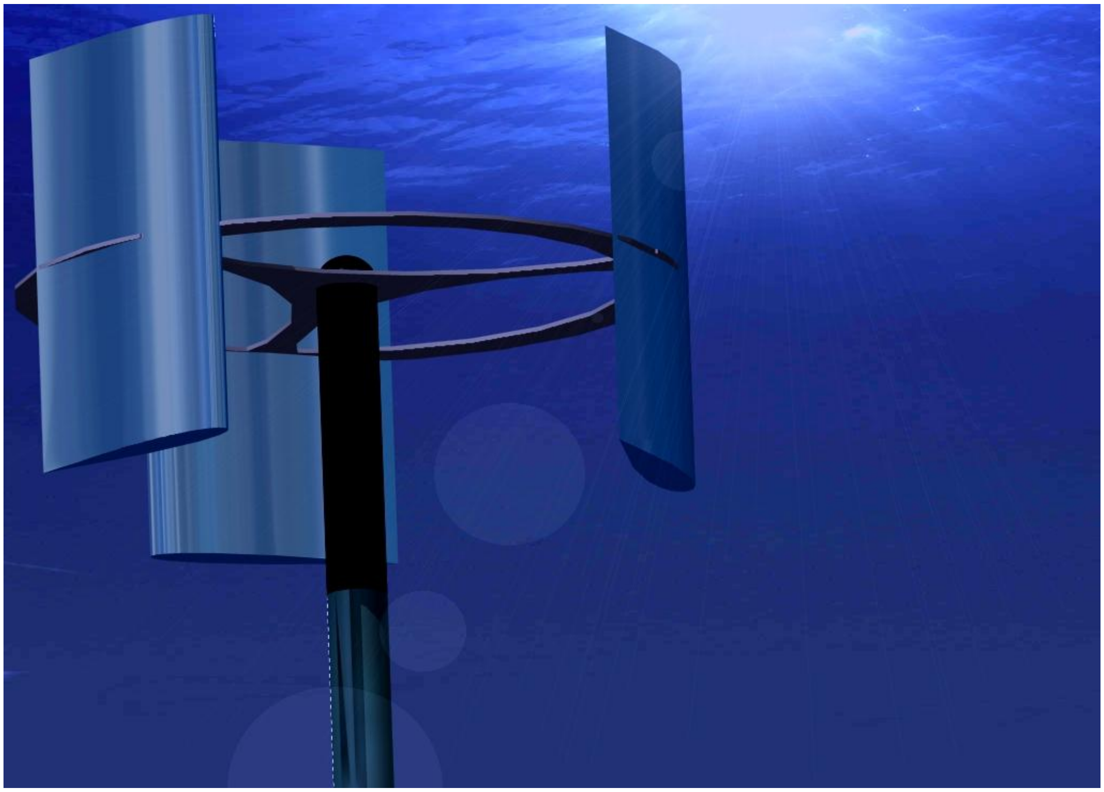
4.2.2 Tidal In-Stream Energy Conversion (TISEC)

TISECs require flowing ocean currents to turn a rotating element, converting mechanical rotational movement into electrical energy. This is similar to the technology used in the wind industry but since water is much denser than air, the energy potential of tidal currents is significantly higher than that of wind (E3 Inc. 2007). As a result, TISEC turbines can be built considerably smaller than those used for the conversion of wind energy.

TISEC devices are generally categorized by the orientation of the axis from which the turbine is suspended. In horizontal axis TISECs, which are the most common, the axis is parallel to the sea surface and current flow direction. Horizontal axis turbines most closely resemble modern wind turbines and extract energy from moving water in much the same way as wind turbines extract energy from air currents. The AK-1000 manufactured by Atlantis Resources Corp. (Figure 12 below) is a typical horizontal axis turbine.

TISEC devices with vertical axis are perpendicular to the sea floor and ocean surface (Figure 8). Vertical axis designs have the advantage that their response to current flow is independent of the direction of the flow: i.e., unlike horizontal axis devices, they do not need to be re-oriented if the direction of the current changes. Consequently, vertical axis turbines may be more suitable in situations where the direction of the current changes significantly during the tidal cycle, as is common in coastal sites and many inter-island passages. On the other hand, vertical axis turbines have a tendency to stall when the water stops flowing, requiring a mechanism for restarting when flow returns. (For this reason, vertical axis devices may be especially suited to river locations where the flow never stops.) Less common designs include the oscillating hydrofoil and a duct-protected turbine that exploits the Venturi effect to increase the efficiency of tidal energy extraction. These designs are currently in very early stages of development, and their lower energy conversion efficiencies seem likely to limit their applicability to most tidal energy sites.

Figure 8. Conceptual Vertical Axis Tidal Turbine



Source: University of Strathclyde

TISEC devices are typically composed of rotor blades (converting kinetic energy from currents into rotational movement), the drive train (consisting of a gear box and generator to convert the rotational movement into electricity) and a base structure (supporting the rotor blades and drive train). Each of these components can be further categorized by specific characteristics. Rotors can be either open to the flow of water or can be shrouded or ducted, blades can be either fixed or have a variable pitch, and the base structure can be mounted to the bottom, supported by pylons or towers, or can be tethered to a bridge or dock (E3 Inc. 2007).

Large scale TISECs are typically deployed in 30-50 m of water while smaller devices are suitable for shallower locations closer to shore. TISECs rest on the seafloor fixed in place by a weighted gravity base or mounted on piles in a similar way to offshore wind turbines. Floating units may use a flexible tether to attach to the seabed, a rigid mooring or a floating platform that rises and falls with the tide (Renewable UK 2011).

The tidal industry has not yet converged on a single general design which has prevailed over the others (Statens vegvesen 2012). Presently there are at least 20 different types of TISEC devices on the market at various stages of development (OEER Association 2008). Most TISEC devices are still in the conceptual stages or have been tested in short-term trials. Several technologies (described below) have been demonstrated for extended periods and are approaching the final pre-commercialization or commercialization stage of development.

OpenHydro (OpenHydro-DCNS, Ireland). The OpenHydro turbine was deployed at EMEC in 2007 and became the first tidal energy company to deliver electricity to the UK grid in 2008. A larger OpenHydro turbine was installed in the Bay of Fundy in 2010, but this unit was not connected by cable (Figure 9). The company is currently pursuing projects in France, the US, Scotland and Ireland.

Figure 9. OpenHydro Technology (Horizontal Axis)

Source: www.openhydro.com

TidGen™ (Ocean Renewable Power Company, US). The ORPC unit was deployed in Cobscook Bay near the border between Maine and New Brunswick in July 2012. This small scale unit is the first grid connected tidal project in the US and will generate up to 180 kW of electricity. The ORPC unit is modular and scaleable; the company also has designs for run-of-river and deep ocean installations. Established in 2004, ORPC is advancing projects in Alaska and Florida.

Figure 10. TidGen™ Technology (Horizontal Axis)

Source: Used by permission of ORPC (see also, www.orpc.co)

Beluga 9 (Clean Current, Canada). Originally developed in Canada and tested since 2008 at Race Rocks Ecological Reserve in BC, this unit has been redesigned for commercialization. The company is also planning to install their Orca 7 unit in Paimpol, France in 2013. The company has four models ranging in diameter from 3.5 m (65 kW output) to 10 m (500 kW output).

Figure 11. Beluga 9™ Technology (Horizontal Axis)

Source: www.usinenouvelle.com

AK-1000 (Atlantis Resources Corp., Australia). Atlantis installed a grid connected 100 kW prototype in San Remo, Victoria, Australia, in 2006. This unit was replaced with the 150 kW Nereus I unit in 2008. In 2010, an Atlantis-led consortium received authorization to install a 400 MW turbine array in Pentland Firth, Scotland, which it plans to complete by 2020. The AK-1000 turbine will also be tested at EMEC in Orkney and, in partnership with Lockheed Martin and Irving Shipbuilding, at the FORCE site in Nova Scotia.

Figure 12. Atlantis AK1000 (Horizontal Axis)

Source: www.atlantisresourcescorporation.com

HS1000 (Andritz Hydro Hammerfest, Norway). Established in 1997, this company develops and supplies turn-key tidal power arrays for international power companies. A 300 kW prototype was installed in Finnmark, northern Norway in 2003 and was grid connected in 2004. The company is currently proceeding through the Environmental Impact Assessment process for their 10 MW pre-commercial array project in the Sound of Islay (Scotland), which was approved by the Scottish Government in March 2011. This project will employ ten 1 MW capacity HS1000 mark turbines.

Figure 13. HS1000™ Technology (Horizontal Axis)

Source: www.hammerfeststrom.com

SeaFlow and SeaGen (Marine Current Turbines-Siemens, UK). In 2008, MCT installed the 1.2 MW SeaGen device in Strangford Lough, Northern Ireland. The Strangford Lough SeaGen device reached its five year installation anniversary on April 2, 2013 and remains the world's largest grid-connected tidal stream turbine. It has generated more than 7 GWh of power into the electricity grid (Marine Current Turbines, 2012a).

MCT is currently developing an 8 MW array in Kyle Rhea, which lies between the Isle of Skye and the west coast of Scotland in approximately 30-35 m water depth. It is proposed that the turbine array will be under construction by 2015 and operated for up to 25 years, where it will serve as a test case for the development of the tidal energy technology (Marine Current Turbines, 2013).

Marine Current Turbines is currently partnered with Minas Energy to deploy the latest generation SeaGen device at the FORCE site in Minas Passage. Deployment of a 1.5 MW tidal generator will occur once the subsea cables have been installed at the FORCE site.

Figure 14. Marine Current Turbines Seagen Technology

Source: marinecurrentturbines.com

Pulse Stream (Pulse Tidal, UK). In 2009 Pulse Tidal installed a 100 kW grid connected oscillating hydrofoil unit in the Humber River estuary. Building on this prototype, the company is designing a 1.2 MW commercial scale device for deployment in 2014 in the South West Marine Energy Park off Lynmouth, UK.

Delta Stream (Tidal Energy Ltd, South Wales). TEL has been testing various horizontal axis turbine components in tidal environments since the early 2000s. The first full-scale 1.2 MW Delta Stream unit is currently being deployed in Ramsey Sound, Pembrokeshire for a 12 month test period.

TGL (Tidal Generation Ltd, UK). Tidal Generation assembled a 500 kW device in 2005 that was installed and grid connected at EMEC in 2010. The unit continues to produce electricity as of late 2012. Purchased by Rolls-Royce in 2009, the company was then acquired by Alstom Hydro in 2012. The company is currently designing a 1 MW pre-commercial unit that will be deployed in a 10 MW demonstration array in 2013.

Triton (TidalStream, UK). Built by a company started in 2005, the Triton device has passed through tank testing, modeling and testing in the Thames River. There are two versions: one that can mount three turbines and one that can mount six turbines on two cross arms. The turbines are 20 m in diameter. The Triton system relies on a mounting frame to host multiple turbines (up to 10 MW on a single frame), which in turn reduces overall project costs. TidalStream is currently focused on designing a 3MW installation.

Voith HyTide 1000-16 (Voith Hydro Ocean Current Technologies). Voith has operated a 110 kW test turbine near the South Korean island of Jindo since 2011. A 1 MW grid connected device was deployed at EMEC in 2011 and is currently undergoing additional testing.

Generation 5 (Verdant Power, US). In early 2012 the Federal Energy Regulatory Commission issued the first commercial license for tidal power in the US to Verdant Power. Building on the 2006-2008 testing of its technology in the East River (New York), Verdant is approved to install up to 30 turbines in the East River, making up a 1 MW pilot tidal energy project. Verdant is also exploring project opportunities in Canada at their early stage Cornwall Ontario River (CORE) Project, where it plans to install two 60-80 kW turbines in a run-of-river environment.

Free Flow Power Free Flow Power is currently working towards licensing 25 permitted projects in the Lower Mississippi River between Kentucky and Louisiana. The powerful currents of the Lower Mississippi render it the ideal environment for in-stream hydrokinetic development. The 25 permitted projects in the Mississippi would generate 3,303 MW (Free Flow Power 2013).

BlueTEC™ (Bluewater). Bluewater's Tidal Energy Converter (BlueTEC™) is a floating platform designed to accommodate either horizontal axis or vertical axis turbines. According to the company, the floating platform allows for easier and less expensive access and maintenance, while situating critical components above the waterline.

Schottel Tidal Generator STG 50 (Schottel: Group) Built by a well known marine propulsion and engineering firm, the STG 50 is a 50kW, 4.5 m diameter horizontal axis free flow turbine (i.e., there are no ducts that help accelerate the water onto the turbine blades). It requires approximately 2.5 m/s current to operate efficiently but may operate in currents of up to 5.0 m/s. According to the company, this turbine is robust, simple, lightweight and low cost. Its modular design allows for scaling up initial small projects into larger arrays where conditions are suitable. Full scale tests have been conducted with the turbine fixed to a tug, but as of late 2012, no stand along STG 50 TISECs has been deployed. In June, 2013, Schottel announced that two STG 50 turbines will be mounted on a platform manufactured by Sustainable Marine Energy and the 100 kW community scale demonstration project tested off the Isle of Wight, UK.

Table 1 summarizes past, current and planned tidal energy projects around the world. Of particular interest is the observation that past and current projects are largely single turbine demonstration deployments, while proposed projects are principally multi-unit commercial or pre-commercial arrays.

Table 1. Past, Current, and Planned Tidal Energy Projects

Tidal Energy Projects – Past and Current								
Company, Based in	**Year**	**Partners**	**Technology**	**Site**	**Power**	**Depth**	**Other**	**# Units**
OpenHydro-DCNS, Ireland	2007	Highlands and Islands Enterprise (HIE) and unnamed partners	Axial-flow turbine	EMEC (Orkney Is.) UK	250 kW	25 - 40 m	-	1
OpenHydro, Ireland	2010	Nova Scotia Power Inc.	Axial-flow turbine	FORCE, NS	1 MW	30 m	Not connected by cable	1
Ocean Renewable Power Company, USA	2012	Bangor Hydro Electric	Cross Flow Turbine (TidGen unit)	Cobscook Bay, USA	300 kW	30 m	Grid connected tidal	5
Atlantis Resources Corp, Australia	2006	-	Nereus 1	San Remo, Victoria, Australia	100 kW	Not Available	Grid connected prototype	1
Atlantis Resources Corp, Australia	2008	Morgan Stanley	Nereus 1 (AN-150)	San Remo, Victoria, Australia	150 kW	Shallow Water	Grid connected prototype	1
Atlantis Resources Corp, Australia	2008	Morgan Stanley	Nereus II (AN-400)	San Remo, Victoria, Australia	400 kW	Shallow Water	Grid connected prototype	1
Atlantis Resources Corp, Australia	2008	Morgan Stanley	AS-500	Singapore	100 KW - 1 MW	Not Available	Grid connected prototype	1
Andritz Hydro Hammerfest, Norway	2003/2004	-	HS300 Turn-key Turbine	Finnmark, Norway	300 kW	50 m	Turn-key tidal power arrays - prototype & grid connected	1
Marine Current Turbines, UK	2008	Siemens	SeaGen	Strangford Lough, Northern Ireland	1.2 MW	Suitable for depths up to 38 m	Grid connected tidal stream turbine	1
Pulse Tidal, UK	2009	Marubeni, IT Power	Pulse-Stream 100	Humber River estuary, UK	100 kW	9 m	Grid connected oscillating hydrofoil unit	1
Tidal Generation Ltd., UK	2010	-	Axial-flow turbine	EMEC, (Orkney Is.) UK	500 kW	25 - 40 m	Grid connected	1
Tidal Generation Ltd., UK	2013	Alstom	Axial-flow turbine	EMEC, (Orkney Is.) UK	1 MW	35 - 80 m	Grid connected	1
Voith Hydro Ocean Current Technologies, Germany	2011	RWE Innogy Venture Capital Fund	Voith HyTide 1000-16 (horizontal axis turbine)	Sea Turtle Tidal Park, Jindo, South Korea	110 kW	Not Available	Test turbine	1

Voith Hydro Ocean Current Technologies, Germany	2012	RWE Innogy Venture Capital Fund	Voith HyTide 1000-16 (horizontal axis turbine)	EMEC, Scotland	1 MW	25 - 40 m	Grid connect device - undergoing testing	1
Verdant Power , USA	2012	-	Generation 5 (horizontal axis turbines)	East River, NY (RITE Project)	1 MW	<40 m	Commercial array, currently at Phase 3 buildout	30
Tidal Energy Projects - Planned								
Company, Based in	**Year**	**Partners**	**Technology**	**Site**	**Power**	**Water Depth**	**Other**	**# Units**
OpenHydro, Ireland	2012	Bord Gais Hydro	16 m diameter 2 MW Turbines	Torr Head, Antrim	100 MW	Not Available	Tidal energy farm	Array
OpenHydro, Ireland	2012	EDF - French Utility	16 m diameter 2 MW Turbines	Brittany, near Paimpol in Cotes-de'Amor	2MW	35 m	Tidal farm - commissioning tests	4
Atlantis Resources Corp, Australia	2020	Morgan Stanley, International Power GDF Suez	AR-1000 Series	Pendtland Firth, Scotland	398 MW	Not Available	Turbine array	Array
Atlantis Resources Corp, Australia		Lockheed Martin, Irving Shipbuilding	AR-1000 Series	FORCE , NS	1 MW	30-40 m	Grid connected	1
Andritz Hydro Hammerfest, Norway	2011	Scottish Power Renewables (SPR)	HS1000 mark turbines	Sound of Islay, Scotland	10 MW (ten 1 MW capacity)	Not Available	Pre-commercial array	10
Marine Current Turbines, UK	2015	Siemens Energy	SeaGen	Kyle Rhea (between Isle of Skye & west coast of Scotland)	8 MW array	30-35 m	Test case - turbine array	4
Marine Current Turbines, UK	2015	Siemens Energy	SeaGen	North of Anglesey, North Wales	10 MW	20-40 m	Skerries Tidal Stream Array - commerical tidal energy farm	Up to 9
Marine Current Turbines, UK	2017/2020	Siemens Energy, Carbon Trust, EDF Energy	SeaGen	Brough Ness, Orkney Islands, Scotland	99 MW	Not Available	Tidal Farm - Commissioning Tests	66
Marine Current Turbines, UK	2015	Minas Basin Pulp & Power	SeaGen U device	FORCE, NS	3 MW	30-40 m	Tidal Generator - grid connection	3
Marine Current Turbines, UK	2015 / 2020	ESB International, Guernsey Electric, Triodos Bank, EDF and others	SeaGen	Pentland Firth	50 MW (2015); 300 MW (2020)	Not Available	Grid connected tidal array	40+

Pulse Tidal, UK	2014	Marubeni, IT Power	Pulse-Stream	South West Marine Energy Park off Lynmouth, UK	1.2 MW	18 m	Commercial scale single device	1
Triton (TidalStream, UK)	-	-	Triton 6: turbine mounting on cross arms - turbines 20 m in diameter	In development	3 MW	Not Available	Mounting frame to host multiple turbines (up to 10 MW on a single frame)	?
Verdant Power, US	2012+	Ontario Ministry of Research and Innovation; Innovation Demonstration Fund. Sustainable Development Technology Canada (SDTC)	Free Flow Kinetic Hydropower System (Horizontal Axis Turbine)	Cornwall Ontario River, Ontario (CORE project)	15 MW	Not Available	Run of river environment	3
Tidal Energy Ltd, UK	2013/2014	Eco2 Ltd, Carbon Connections UK Ltd, Cranfield University	Delta Stream unit	Ramsey Sound, Pembrokeshire, UK	1.2 MW	33 m	Horizontal axis turbine	1
Tidal Generation Ltd., UK	2014/2016	Alstom	Array of Axial-flow turbines	EMEC, (Orkney Is.) UK	4-10 MW	25-40 m	To be grid connected	10

4.3 Commercial Tidal Project Operating Requirements

Large scale TISECs are 1-2 MW in output and are typically deployed in 30-50 m of water. Large scale arrays are expected to remain within 100 km of shore, and probably will be installed considerably closer (within 10 km of shore). Small scale TISECs of 500 kW output or less are suitable for shallower locations and will be deployed much closer to shore, typically within two kilometers. Large scale arrays may occupy from 0.5 km^2 of seafloor (20 units) to 2.2 km^2 (100 units), although the spacing between devices will vary and so actual array size is not clearly known at this time. Minimum current speeds of 1.0 – 1.2 m/s are required for small scale developments while larger units generally require peak spring current flows of greater than 1.2 m/s.

Table 2 summarizes the general operating parameters of TISEC technologies.

Table 2. Technology Operating Parameters

Operating Parameter	Small Scale Tidal*	Large Scale Tidal
Average Water Depth	10 m to 30 m	20 m to 80 m
Maximum distance from shoreline – based on maximum distance for AC export cables	5 km	100 km
Constraining Threshold	Peak Spring Current Flow >1.0 m/s	Peak Spring Current Flow >1.2 m/s
Approximate MW/km^2	Not available	50
Average Turbine/Device Generating Capacity	100-500 kW	1 MW or greater
Cost to Generate Power ($CAD)	Not available	$0.44 to 0.51 per kWh
Average Scale of Commercial Development / Array Size	1-3 MW	50MW
	500 m^2	1 km^2

(Source: Modified from AECOM 2010); *estimated values – this study

Information related to the general operating requirements for tidal lagoons is not available.

5. Tidal Energy Development Scenarios

Section Summary

This section presents a series of tidal energy development scenario for projects of differing scale and level of advancement. Areas of interest to tidal energy developers within the Bay of Fundy are shown, and the challenges to deploying projects in these high energy environments are listed. The final section also describes the anticipated timelines to commercial tidal energy in Nova Scotia.

5.1 Overview

The successful introduction of any new industry to a region is a complex process dependent on a host of variables. In the case of the tidal energy industry, which has not yet reached an economically viable stage of development and for which no truly commercial projects exist, it is much more difficult to predict and describe the course that may be taken in the Bay of Fundy.

As tidal energy projects have evolved from the laboratory to test tanks to ocean deployment, a series of development steps has been defined that chart how these technologies mature over time. These steps are: *pilot phase, demonstration phase* (non-grid connected and grid connected), and *commercial phase*. The tidal industry is now sufficiently developed that TISEC developers are testing grid-connected pre-commercial single units and will deploy in the near future pre-commercial and commercial arrays in different areas around the world. Given this state of development, project promoters in the Bay of Fundy will likely seek to test grid-connected units or small arrays to assess their commercial viability and attract investment capital.

This first step in developing a tidal energy project is to identify one or more potential locations for the proposed project. A suitable project site depends on a number of legislative, technical, physical, environmental and economic factors. More detailed information and in-depth site assessments will be required at later stages in the project development. With respect to legislative requirements, all projects require a clear understanding of the authority and duties of the provincial and federal levels of government, the Mi'kmaq perspective, and an appreciation of the permitting and seabed leasing process. The "permitting roadmap' is established at the earliest possible stage so that all participants understand the expectations and timelines of the permitting agencies and the stakeholder consultation process.

5.2 Siting and Oceanographic Considerations

The list below outlines the technical and environmental information that must be obtained and assessed for a tidal energy project to proceed. These information requirements apply in a general sense to all tidal energy projects; data requirements will vary at each site to reflect specific physical or biological characteristics.

Technical and Physical Considerations

Tidal Resource Availability: this will vary from site to site and between technology types, but generally speaking project developers require currently speeds on the order of 1.5 – 2.0 m/s (5.4 - 7.2 km/hr). The site must maximize the opportunity for energy extraction. The tidal range and tidal current velocities should be well characterized in three dimensions throughout the water column where generators will be placed. Knowledge requirements include the depth averaged, in-stream power density at ebb and flood peak flows, as well as the mean energy flux per tidal cycle, and the annual average energy flux per unit aperture area of TISEC device (EPRI 2006). Since the tidal currents should be linear (non-turbulent), estimates of channel bottom and side friction coefficients and vertical velocities should be determined as well. Water turbulence should be avoided. Using these metrics, the power output of various TISEC devices may be predicted for any given installation (MacMillan *et al.* 2012).

Bathymetry: The selected site must have appropriate water depths to prevent navigational hazards and operate efficiently. Large scale turbines with 20-25 m diameter rotors and 1 MW or more capacity typically require deeper water than smaller capacity units designed for community energy projects. The larger turbines are installed in 30-70 m water depth while smaller versions may occupy depths of 10-30 m.

Seabed Morphology: the shape and composition of the seabed must be appropriate for the installation of the TISECs, their mooring lines and subsea electrical cables. A hard, flat bottom substrate of exposed bedrock is preferable to erodible unconsolidated sediments and the deployment area should be free of changing “bedforms” – deposits of sediments that move with the currents.

Logistics: Installation, operations and maintenance of TISECs require suitable harbour facilities nearby, and specialist services such as work boats, divers, and instrumentation experts.

Grid Connection: The project should be located in close proximity to a transmission grid having sufficient capacity to accept the electrical load. In addition, a suitable landfall location must be available to allow connection to the electrical grid. To the extent possible the landfall must be free of technical, environmental and economic constraints that will negatively affect the project.

Environmental and Social Considerations

Designated/Protected Areas: International, national, provincial, and regional protected areas are generally not suitable for MRE projects. An exception would be multiple use protected areas that include sustainable human development as a management goal. Military test sites and former ordinance disposal sites must also be identified and avoided.

Ecology: The site selection process must evaluate the ecological sensitivity of potential sites and avoid those that have essential habitat for, or critical concentrations of, protected species (e.g. species at risk)[7]. Typical organisms of this category include certain populations of some species of birds, cetaceans, fish, and shellfish. Habitat includes not only environments and locales where organisms shelter, feed and breed, but also transit corridors that allow essential connection between such habitats.

Archaeology and Historical Heritage: Shipwrecks and flooded archeological sites (including shoreline Mi’kmaq historical sites) must be identified and, to the extent possible or required by regulators, avoided.

Traditional Use of Resources by Aboriginal Peoples: Aboriginal people often enjoy a special relationship to the natural world. There is a legal duty to consult First Nation peoples during the planning and evaluation of any of development that may have an effect upon their traditional access to natural resources. In the Bay of Fundy, Mi’kmaq Ecological Knowledge Studies (MEKS) have been conducted to identify areas of historical significance and on-going use of marine and coastal resources that might be affected by marine energy extraction (MGS 2009; MGS 2012). These uses typically include food, societal and ceremonial fisheries practices by Aboriginal Peoples.

Other Marine Users and Infrastructure: Since MRE projects share the ocean with various other user groups and may impinge on existing infrastructure, logistics and resources, these factors must be understood in detail. Examples of other uses include recreational and commercial fishing, recreational and commercial navigation, water

[7] *It is notable that TISECs tested at Race Rocks (BC) and Strangford Lough (Northern Ireland) were deployed in ecologically sensitive areas. It is also the case that the high current areas of interest in the Bay of Fundy coincide with areas of significant habitat and species at risk.*

sports (skiing, diving, surfing) and military activities. Existing infrastructure may include cables, pipelines, and aggregate mining.

Consultation: In addition to the legal (regulatory) requirements to consult or engage local aboriginal and non-aboriginal populations, the site selection process will benefit from local knowledge and expertise to identify constraints to development and propose mitigation measures to lessen impacts. This potential benefit encompasses the social-cultural spectrum from local communities of residence to specialized institutions (e.g. universities).

5.3 Tidal Development Project Types

5.3.1 Commercial Models

The tidal energy industry has evolved considerably since 2008 when the Bay of Fundy SEA was completed. Two fundamental changes have occurred that will influence how tidal energy projects are developed in the Bay of Fundy.

- First, more and more TISECs are at the commercialization stage and so some project proponents are now seeking sites that can host arrays of TISECs for commercial purposes. Where arrays are proposed, the project site must not only meet the minimum requirements to test the turbine but also must meet the broader requirements of a commercial project. (It should also be noted that many project developers are still seeking single-berth deployment sites to test individual units).

- A second change since 2008 is that the industry has developed two distinct project scales, each targeting different electricity markets. On the one hand, large scale projects designed to *transmit* electricity for sale consist of large diameter turbine arrays deployed in high current, deep water environments, typically 1-10 km offshore. These projects are generally >10 MW in total and follow the offshore wind energy model. On the other hand, smaller scale units suited to lower current speeds can be deployed in shallow water nearer to shore with the ultimate objective of *distributing* electricity to local consumers where power costs are high. Projects that serve this community model are typically less than 5 MW and may be less than 1 MW. The small scale model is also being developed for run-of-river applications and installation in hydroelectric dam tail races, canals and power plant water discharges.

In Nova Scotia, the differences between these two models are represented by the large scale test site in Minas Passage (FORCE) which ultimately aims to *transmit* power, compared to the small scale projects proposed for locations in Bras d'Or Lakes and near Digby which aim to *distribute* power to the local communities[8]. Over the long term, both models are commercially-oriented although both must proceed through demonstration phases to achieve commercialization.

The technological differences between large and small scale projects are likely to increase rather than decrease in the future. Large project developers are scaling up their plans to take advantage of efficiencies gained by mass production of turbines and other project components while smaller developers are looking to lighten their units and custom design them to fit into the remaining unconstrained nearshore areas open to their projects.

The industry is trending toward the installation of multiple arrays in different tidal environments. This will allow manufacturers to design, produce and sell turbines and other components, which in turn reduce their costs and stimulates the industry to advance. Remaining critical challenges to this industry are the development of electrical connectors and techniques for use in subsea high current environments (unlike the offshore wind where cables run up the shaft and can be connected in the dry), optimization of foundation designs, and an understanding of "wake

[8] *Small scale projects can **distribute** electricity to nearby communities but cannot **transmit** power over extended distances for sale or use elsewhere. Small scale projects do not generate enough power to overcome natural losses that occur curing transmission.*

effects" where multiple turbines interfere with each other by causing turbulence in the tidal stream reducing energy extraction efficiency. Further work is also required to reduce deployment costs for both the turbines and subsea cables.

In addition to the physical site characteristics required for project developers (peak flow, power density, appropriate water depths and channel widths, proximity to transmission assets), a Developmental FIT is also a critical driver of this nascent industry[9]. A FIT gives the project developer an end market and fixed price for the electricity generated and provides financial return to offset project costs. This allows investors to understand how a project can be financed and how their capital will be recovered over the lifetime of the project. Since the early stages of any industry are the most expensive, this allows developers to move quickly into the market, develop a client base for a particular technology type and demonstrate return on investment to new clients.

The sections below describe and provide examples of several different project types that have been developed elsewhere in the world.

5.3.2 Pilot & Non-Grid Connected Projects

A pilot project is a short-term TISEC deployment focused on testing the technical feasibility of the design. Pilot projects may deploy reduced-scale prototypes or partial TISECs intended to test specific design features.

The intention of the pilot project is to evaluate the device's performance, to confirm theoretical power generation calculations, and to determine on a preliminary basis the feasibility of a demonstration project or commercial application. Of the many different designs that undergo pilot testing, some are found to be technically or economically unfeasible and do not make it to the demonstration stage.

5.3.3 Demonstration Projects

A demonstration project deploys the full scale or near full scale device under natural tidal conditions in order to "demonstrate" commercial viability. Installation at a demonstration facility allows the developer to test deployment and retrieval technology and cost, energy conversion and electrical performance, and understand impacts to and from the tidal environment.

Compared to pilot deployments, demonstration projects are larger and more expensive undertakings and are completed to evaluate a particular TISEC in a long-term operating scenario. Demonstration TISECs are full scale, typically grid connected units, almost but not quite commercial ready. Areas of interest evaluated during the demonstration phase include the device's energy-generating potential and efficiency, device component durability and maintenance requirements, deployment and retrieval costs, and the potential effects of the unit on the surrounding marine environment. These projects are in large part aimed at proving the commercial viability of the device in order to attract the considerable investment capital required for commercialization. At the same time they also provide regulators and the general public with the opportunity to learn about the technology and evaluate its potential impact.

The size of the demonstration scenario varies by project, but individual full scale TISECs typically generate 1.0 to 2.0 MW of electricity. Although grid-connected, projects at the demonstration stage do not rely on the electricity generated to provide a return on investment, but payment for electricity does help to financially support the project.
The opening of demonstration facilities around the world, including the FORCE site in Minas Passage, represents significant progress in the MRE industry since the Phase I SEA was completed in 2008. A considerable body of

[9] Developmental FITs currently under review by the UARB are for testing and demonstration purposes only. No long-term FITs for commercial power production are currently being proposed.

information relating to device performance, technical innovation, and the effects on the environment is now available to guide future project development.

5.3.4 Commercial Sites and Array Sizes

Commercial development is the final stage where grid-connected devices or device arrays are deployed for commercial power generation. Pre-commercial arrays of five to six TISECs are in the planning stages in the UK. For larger tidal arrays, the spacing between TISECs is about 10 times larger in the direction of the flow than perpendicular to it. Currently, it is expected that early large scale arrays will be formed of 1 or 2 rows of about 10 devices each. Such arrays would cover an area of much less than 0.5 km^2 (a “box” measuring approximately 700 m by 700 m), and generate an estimated 50-60 MW/km^2 (AECOM 2010). It should be underlined that no true commercial tidal arrays have yet been deployed, although Verdant Power is progressively building a 1 MW commercial array consisting of 30 low output turbines in East River, New York. Larger spacing between turbines is expected for early pre-commercial arrays to ensure the devices can be easily and safely accessed for maintenance and monitoring.

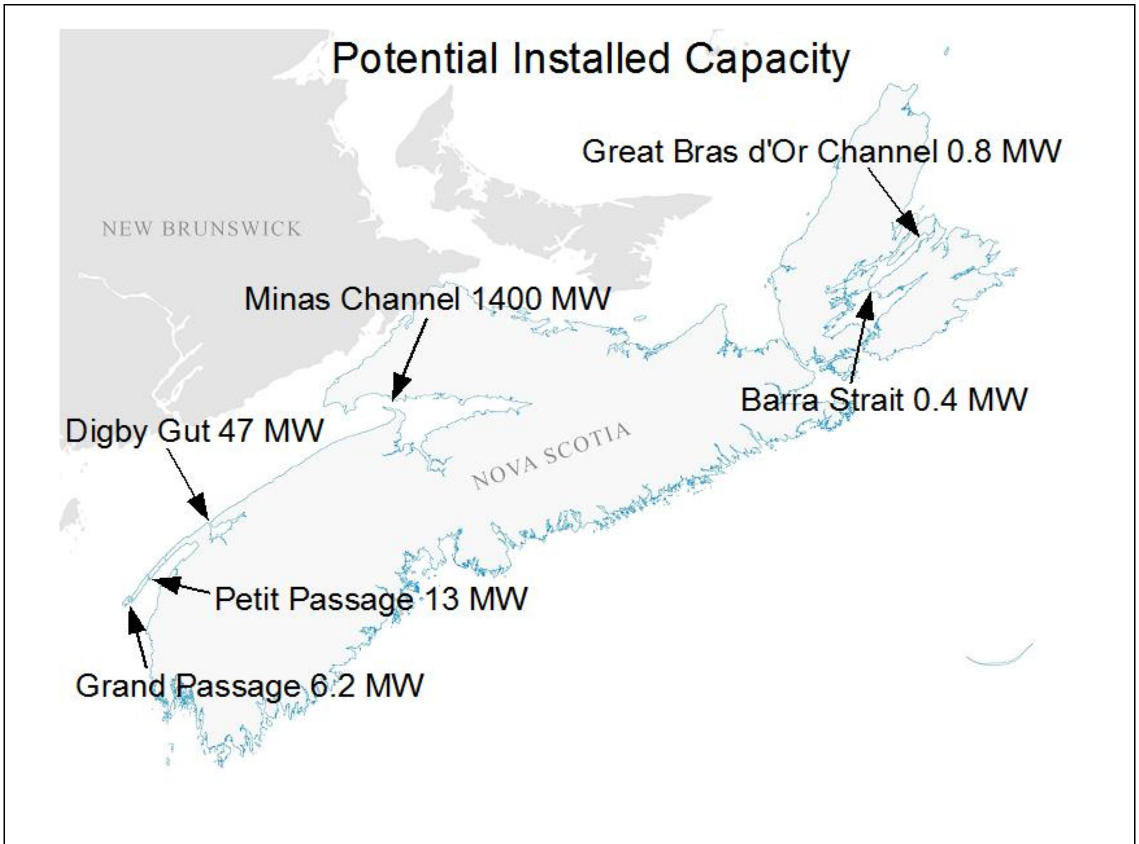
A commercial power generation array may consist of 30 to 100 TISECs capable of generating 30 to 50 MW of electricity. The seabed area occupied by a commercial tidal array depends on the type of device and configuration of the array used. It has been estimated that a 30 unit array would occupy approximately 0.5 $km^{2.}$ or greater (Faber Maunsell and Metoc PLC 2007). An array of 50 to 100 devices, of dimensions 20 m by 50 m, such as MCT’s SeaGen, and requiring 50 m spacing perpendicular to the flow and 200m along the flow, would cover an area of 1.1 to 2.2 km^2 (AECOM 2010). For comparison, Minas Passage is approximately 6 km wide and at least 20 km long (120 km^2). The current Crown Lease for the test berths at the FORCE site is 1.6 km^2, and so occupies only 1.3% of the area of Minas Passage.

Device spacing, and hence array size, will vary due to a number of factors; current estimates of array sizes must be used with caution. A rapid calculation shows that a 10 m diameter 1 MW turbine that requires 50 m on either side from its nearest neighbor plus 100 m separation from upstream and downstream turbines occupies a seabed area of 6,000 m^2. A “box” measuring only 500 m by 500 m could in theory host approximately 40 of these turbines. Smaller turbines that generate less electricity may not need such separation distances, allowing for even greater turbine density in areas of high energy potential.

5.4 Areas of Interest in the Bay of Fundy

Examination of the tidal energy resource in the Bay of Fundy has been extensive since the first assessment was attempted in 2006 (Hagerman *et al.* 2006). Subsequent modeling has reaffirmed the locations in the Bay of Fundy of greatest potential, and has significantly changed the estimated resource estimate. In Nova Scotia waters of the Bay, there are numerous locations that exhibit current velocities in excess of 1.5 m/sec, which is considered the minimum velocity for existing TISEC devices. However, economic factors tend to favour the highest flow areas, which are passages between islands or the entrance to bays. Major locations, with Karsten’s (2013) estimates of Potential Installed Capacity are shown on Figure 1 and Figure 15. Figures 16 through 18 show these areas in more detail, as well as Cobscook Bay in Maine near the New Brunswick border, where the ORPC TISEC was installed in July, 2012.

Figure 15. Potential Installed Tidal Energy Capacity



(Source ATEI 2013)

Based on the tidal resource potential, there are three areas of interest for in-stream tidal energy projects in the Bay of Fundy, and one area that has been suggested for a tidal lagoon development.

5.4.1 FORCE Site, Minas Passage (Figure 16)

The FORCE site, situated in Minas Passage, consists of four berths located 1-3 km from shore in water ranging from 30-60 m deep. The seafloor consists of scoured, exposed bedrock in shallower water, and bouldery sand and gravel in deeper water. All four berths are currently unoccupied. Four subsea cables have been manufactured and are currently stored in Saint John, NB, awaiting installation expected in 2014. Although initially conceived as a demonstration / test facility for single unit deployments, the electrical infrastructure at the FORCE site (subsea cables, terrestrial substation and 10 km power line to Parrsboro) is designed to accommodate commercial-scale arrays with a total capacity of up to 64 MW, should these arrays be approved. The Minas Passage has a potential installed capacity of up to 1400 MW, the largest potential energy resource in the Bay of Fundy. ATEI (2013) estimates that Minas Passage could ultimately host approximately 1000 one megawatt turbines, similar in size to the Open Hydro unit deployed in 2010.

5.4.2 Digby Gut (47 MW), Petit Passage (13 MW), and Grand Passage (6.2 MW) (Figure 17)

An assessment of the in-stream tidal resources in Southwest Nova Scotia - Shelburne, Yarmouth and Digby Counties was conducted as a collaborative effort between Dalhousie University, Acadia University, Nova Scotia Community College and Fundy Tidal Inc. There are three sites in the Digby area with the tidal resource sufficient to support small scale commercial arrays: Digby Gut (47 MW installed capacity), Petit Passage (13 MW installed capacity) and Grand Passage (6.2 MW installed capacity). Preliminary results suggest that other areas of coastal Southwest Nova Scotia may also host tidal currents of sufficient velocity for tidal power development (Trowse *et al.* 2013 a).

Based on resource estimates, it is thought that Digby Gut could ultimately host up to 50 turbines, while Petit and Grand Passages may host 5 to 10 turbines each. Despite this, current distribution grid capacity limits development to 1.95 MW without using storage, smart grid technologies to manage loads, or increasing demand in the future. Fundy Tidal Inc. currently holds COMFIT approvals at Digby Gut – 1.95 MW, Petit Passage – 500 kW and Grand Passage – 500 kW. Work planned for 2013 is focused on detailed site characterization (including flow and seabed analysis) to identify and evaluate potential berth areas for tidal energy deployment. Once a technology partner is selected, Fundy Tidal proposes to begin testing a turbine in one of these berth areas in late 2014 – early 2015 (Morin 2013).

Project outcomes of the Southwest Nova Scotia Resource Assessment include an electronic data set, a report on the resource potential, and input from the local fishermen and coastal communities. Deliverables from the project include:

- Charts with surface flow velocity measurements for several sites in southwest Nova Scotia;
- ADCP flow measurements at Digby Gut, Grand Passage, Petit Passage, and Indian Sluice (Tusket Islands region);
- Recommendations for additional current measurement locations;
- Numerical model predictions of flow and extractable power for Digby Gut, Grand Passage, and Petit Passage; and,
- Tide corrected high resolution multi-beam bathymetry for Grand Passage and Petit Passage available in GIS and latitude, longitude and depth formats.

Preliminary results of this project are presented in Trowse *et al.* (2013a; 2013b) and the full report is available on the OERA website.

5.4.3 Cobscook Bay, Maine. ORPC Deployment (Figure 18)

The ORPC project is the first federally licensed, grid connected tidal energy project (excluding a dam) in the Americas. The project will ultimately consist of a commercial-scale array of multiple grid-connected TidGen™ devices on the sea floor in Cobscook Bay off Eastport and Lubec, Maine (ORPC 2013). The project will proceed in two phases. The first phase is a single, grid connected 150 kW turbine installed in July 2012. The second phase will add four additional 150 kW turbines for a total electrical output of 0.75 MW. Electricity generated by the project is delivered via underwater power cable to an on-shore station in Lubec, Maine, where it is power-conditioned; it was connected to the power grid in September 2012.

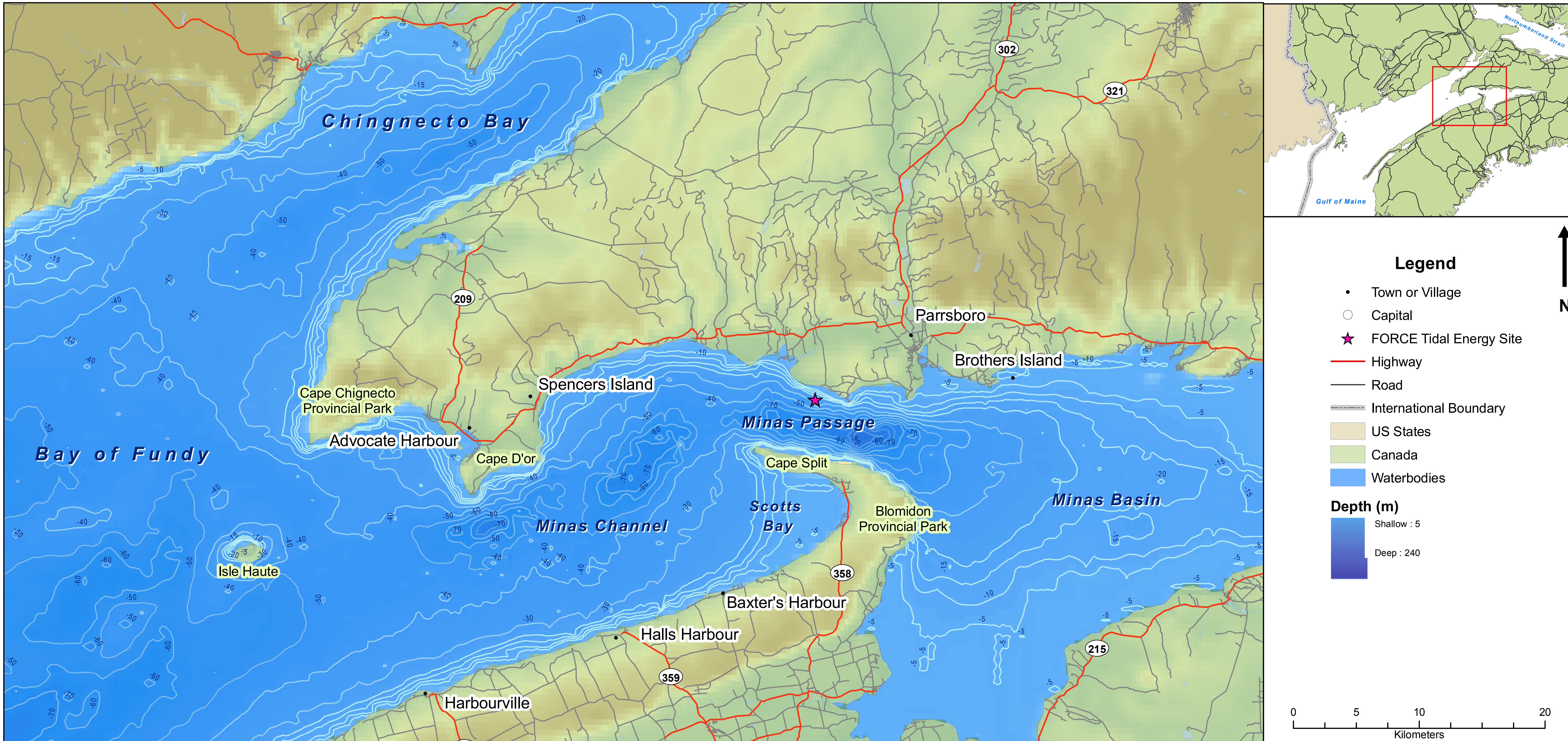
The ORPC turbine is installed in about 30 m of water and is located approximately 1.2 km from shore. As part of its federal licence, ORPC has drafted the following monitoring plans:

- Acoustic Monitoring Plan;
- Benthic and Biofouling Plan;
- Fisheries and Marine Life Interaction Plan;
- Hydraulic Monitoring Plan;
- Marine Mammal Monitoring Plan; and,
- Bird Monitoring Plan.

ORPC's 2012 monitoring results are available here.

5.4.4 Scots Bay, West of Blomidon and Cape Split (Figure 16)

The Scots Bay site has been suggested for a tidal lagoon-type installation, rather than in-stream TISEC deployment. The project would consist of an enclosure from the tip of Cape Split to a point near Baxters Harbour. The enclosure would be approximately 10 km and extend a maximum of approximately 5 km offshore. The enclosure would incorporate 38 powerhouse caissons, housing 304 horizontal bulb turbine-generators with an individual capacity of 3.62 MW and a total installed capacity of 1100 MW (Halcyon 2012). The enclosure walls would rise about 7 meters above mean water level. More detail regarding this project is found in section 3.2.1.



Bay of Fundy

Minas Passage & Channel

September 2013 | 1:300,000 | Datum: NAD83 Zone 20 Source:

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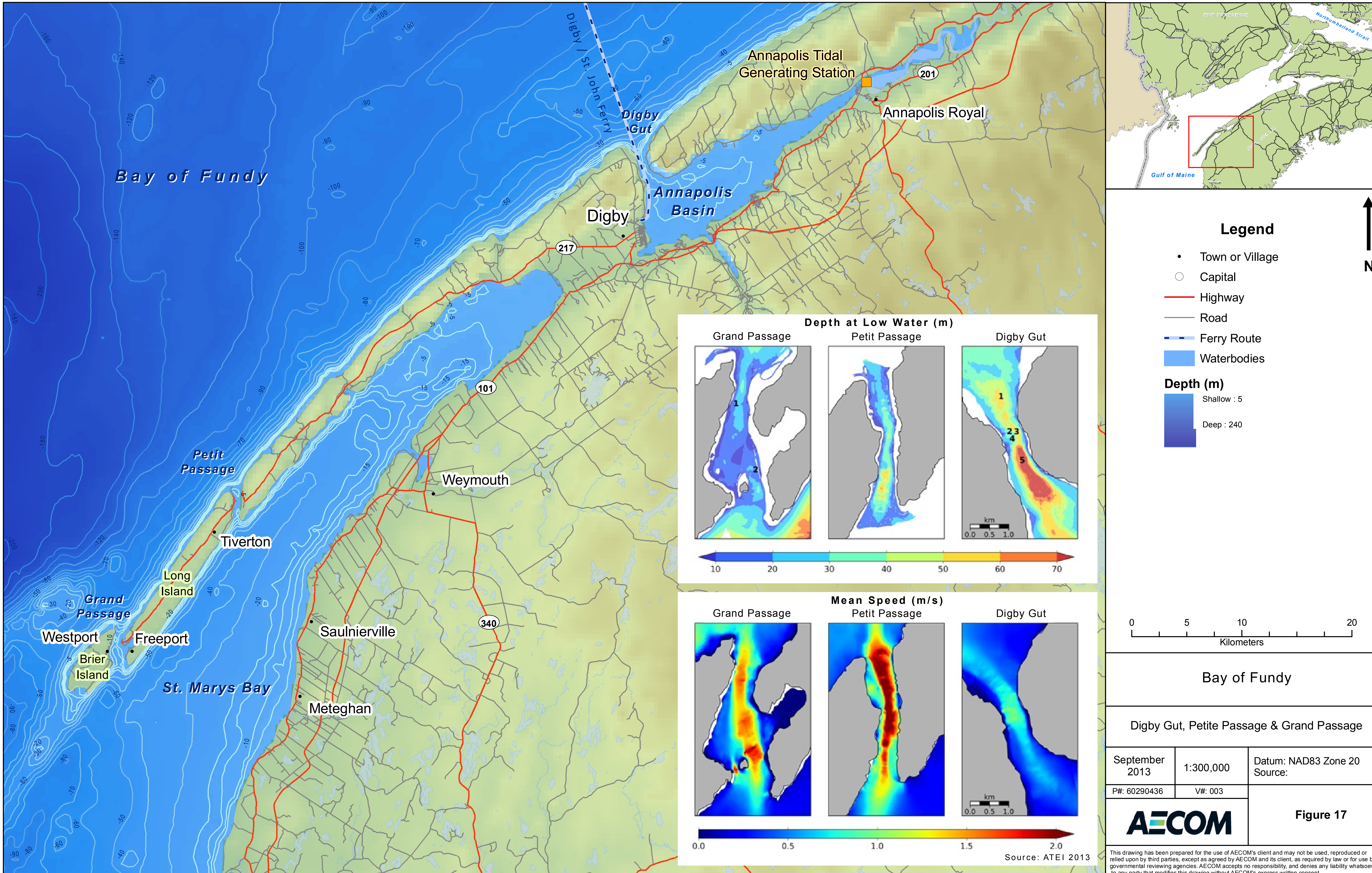
AECOM

Figure 16


Bay of Fundy
Digby / St. John Ferry
Digby Gut
Annapolis Tidal Generating Station
Annapolis Royal
Annapolis Basin
Digby
Petit Passage
Weymouth
Tiverton
Long Island
Grand Passage
Westport
Freeport
Brier Island
St. Marys Bay
Saulnierville
Meteghan
201
217
101
340
Depth at Low Water (m)
Grand Passage
Petit Passage
Digby Gut
km
0.0 0.5 1.0
10 20 30 40 50 60 70
Mean Speed (m/s)
Grand Passage
Petit Passage
Digby Gut
0.0 0.5 1.0 1.5 2.0
Source: ATEI 2013
Gulf of Maine
Legend
Town or Village
Capital
Highway
Road
Ferry Route
Waterbodies
Depth (m)
Shallow : 5
Deep : 240
N
0 5 10 20
Kilometers
Bay of Fundy
Digby Gut, Petite Passage & Grand Passage
September 2013
1:300,000
Datum: NAD83 Zone 20
Source:
P#: 60290436
V#: 003
AECOM
Figure 17
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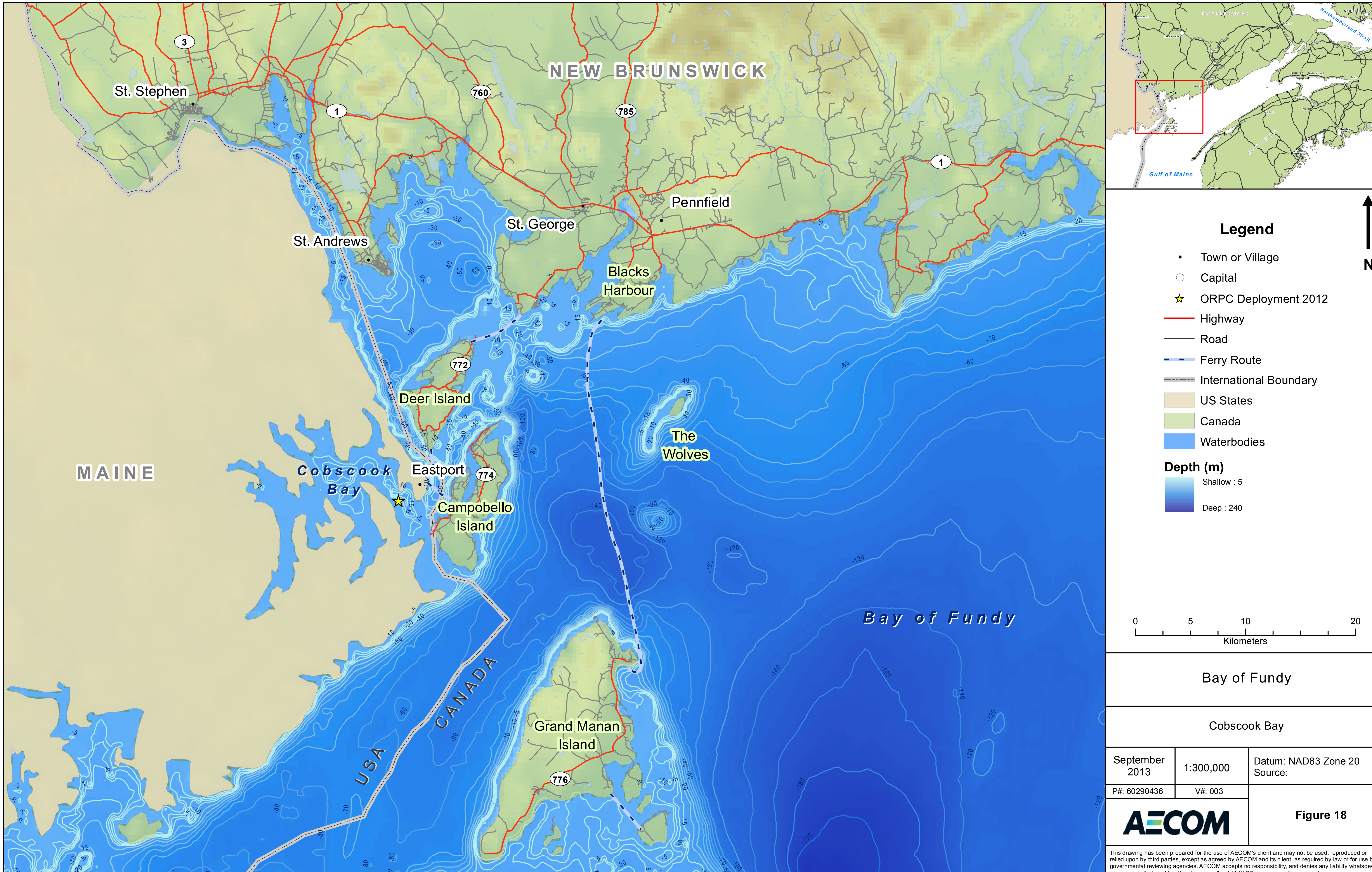
NEW BRUNSWICK
MAINE
St. Stephen
St. Andrews
St. George
Pennfield
Blacks Harbour
Deer Island
Eastport
Cobscook Bay
Campobello Island
The Wolves
Grand Manan Island
Bay of Fundy
CANADA
USA
Gulf of Maine
3
1
760
785
772
774
776
Legend
Town or Village
Capital
ORPC Deployment 2012
Highway
Road
Ferry Route
International Boundary
US States
Canada
Waterbodies
Depth (m)
Shallow : 5
Deep : 240
N
0 5 10 20
Kilometers
Bay of Fundy
Cobscook Bay
September 2013
1:300,000
Datum: NAD83 Zone 20
Source:
P#: 60290436
V#: 003
AECOM
Figure 18
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5.5 Timelines, Challenges and Risks to Commercialization

At this time, there are no fully commercial TISEC arrays in operation, although several grid connected units are providing power in the UK, the US and elsewhere. There are considerable technical challenges to successful commercialization of this technology, and these challenges imply risks to project developers and financial investors (Table 3). These include:

Table 3. Challenges and Risks Associated with Tidal Energy Development

Challenges	Risks
Marine Environment	The harsh conditions require experience and expertise.
Immature Technology	Some TISECs will not perform efficiently and will not meet performance targets.
Installation Techniques	Complex, expensive and may require scarce equipment.
Maintenance Requirements	Significant source of safety, cost and performance risk.
Funding Availability	High cost, high risk, new technology = funding challenges.
Operating Costs	Costs are varied and site-specific, and so are difficult to quantify.
Pricing	Governments and utilities not setting reasonable price targets for first developments.
Environmental Unknowns	Key issues are impacts to fish/mammals; occupation of project area by other users.
Regulatory Hurdles	May result in delays and additional costs.
Tidal Array Power Extraction	Unit spacing and maximum energy extraction levels are not clearly known.
Tidal Resource Identification	Lack of relevant, local current and bathymetric information.
Area Use Conflicts	Lack of clarity on how project areas are allocated between competing marine area users (i.e., fishers, tourism operators, tidal project developers).
Development Risks	New technology + marine environment = risk exposure.

Within Nova Scotia, SLR (2013) identified five technical challenges to the development of commercial-scale tidal energy, and led a workshop with ocean sector technology providers to address and resolve these challenges. The technical issues included:

1. Sensors and instrumentation: assessing the resource, monitoring the devices, and monitoring environmental effects;
2. Deployment and recovery: installation and maintenance of devices and cables;
3. Subsea electrical grid: to transmit and condition the electricity generated by the devices;
4. Turbines/moorings: the devices and equipment that generate the electricity and maintain the position of that equipment and related infrastructure; and,
5. Cabling and connectors: between the land-based infrastructure and the subsea grid, both for electricity and communications.

The marine energy industry has made major strides, achieving much progress in a very short period of time. Many observers believe that the present status of the technology is comparable to that of the emerging wind energy development in the 1980s (Bahaj 2013). However, as tidal energy is currently an emerging industry, there is little direct knowledge regarding commercial capital, operating and maintenance costs. This uncertainty makes it more difficult to attract the investment capital needed to fund the growth of the industry, which in turn will reduce uncertainty and more clearly establish costs.

Plans for multi-megawatt array-scale development are forging ahead, especially in the UK. Most of these sites will need the appropriate infrastructure such as proximity to the grid and suitable ports, as well as buy-in from stakeholders. The cost of such support is demonstrated within the Pentland Firth and Orkney Islands waters 'round

1' leases. In addition to £4 billion estimated cost of the 1.6 GW of potential capacity for different technologies (600 MW wave energy devices, 1000 MW tidal current devices), £1 billion will be required from public sources to develop and build new grid connections, harbours and other supporting infrastructure in the Orkney Islands and Caithness (Crown Estate 2012).

In Nova Scotia, timelines to commercial development are described in the *Marine Renewable Energy Strategy* (NSDOE 2012). The Province continues to take an incremental approach to tidal energy development, with effort directed to legislation that governs tidal energy projects, research, and development projects. With the 2015 and 2020 renewable energy targets now enshrined in law, the Strategy envisions deployment of small scale test devices in the Digby area by 2014 and tidal device arrays at the FORCE site by 2020. The *Strategy* proposes commercially competitive in-stream tidal technology in the post-2020 period.

Over time, manufacturing practices are refined and installation processes are streamlined, reducing the costs. In addition, the cost-per-turbine price falls as more and more units are manufactured and competition increases. It is the early stage of industry development that most benefits from government feed in tariffs, such as the COMFIT and Developmental FIT rates established in Nova Scotia. It is thought that with government commitments to establish favourable regulatory and feed-in regimes as well as the aspiration for energy independence and combating climate change, the progress should be much faster than that achieved for wind energy development (Bahaj 2013).

6. Existing Environment

Section Summary

This section provides an introduction to the ecology and physical oceanography of the Bay of Fundy, and describes some of the socio-economic features of the communities that border it. Marine biophysical characteristics of specific interest to tidal energy projects, such as those features that may be negatively affected by the installation of tidal energy devices, are described. The text describes past and on-going research regarding critical questions surrounding the tidal energy industry, the results of some of that research, and how environmental impacts may be monitored in this challenging environment.

6.1 Physical and Biological Environment Overview

The Background Report to the first Strategic Environmental Assessment of Marine Renewable Energy in the Bay of Fundy describes in considerable detail the existing environment of the Bay of Fundy as a whole (Jacques Whitford 2008). Subsequently, an updated and more detailed account of the current state of knowledge about the Bay was prepared as part of a project for Parks Canada to identify potential Representative Marine Areas of the Bay of Fundy (AECOM 2011). In examining the diversity of habitats in the Bay of Fundy, the AECOM team identified two areas in the Nova Scotia portion of the Bay, the features of which include many distinctive habitats (Figure 35). Both areas coincide with sites of interest for tidal power:

- Scots Bay/Southern Bight of Minas Basin: this proposed Representative Marine Area (RMA) includes the area around and to both sides of Cape Split and Cape Blomidon, to Hall's Harbour in the west and to Cambridge (Hants County) in the east. The area includes deep passages, rocky, gravel and sandy substrates, mudflats and salt marshes, and both clear and turbid water; and,

- Digby Neck/Brier Island: this proposed RMA includes the outer part of St Marys Bay, the south western coast of Nova Scotia to Big Tusket Island, and offshore to Lurcher Shoal. Similar to the Scots Bay/Southern Bight area, the proposed RMA includes marshes, mudflats, sandy, gravelly and rocky substrates, and deeper water extending into the Discovery Channel.

The following section provides a brief synopsis of the information in these two documents, as a basis for an updated consideration of environmental issues relating to tidal power developments in the Nova Scotia portion of the Bay of Fundy.

The Bay of Fundy is an integral part of a complex coastal oceanographic system that includes the Gulf of Maine, Georges and Browns Banks, and the various channels between them. The system is influenced as a whole by the tidal rhythms of the western Atlantic Ocean, but because of past geological history, which determines local morphology, each region of the system tends to respond to tidal forces in a different way, leading to the extremely high tidal range and strong tidal currents that make the Bay of Fundy a globally significant place for development of tidal power.

As pointed out in the original SEA, the Bay of Fundy system is very dynamic in both space and time. The Outer Bay has a wide connection with the Gulf of Maine, experiences tidal ranges averaging 4-7 m, and is also susceptible to strong wind-driven waves. The Upper Bay, in contrast, has very much higher tidal range (in excess of 12 m) and associated strong tidal currents, but is somewhat protected from prevailing winds, and consequently has a less intense wave climate. The geology of the Bay is complex, and includes a variety of rock types primarily of Triassic or Jurassic age: sandstones, siltstones, limestone, chert and basalt (AECOM 2010). In the Outer Bay, bedrock outcrops along the shoreline provide rocky habitat that is covered with seaweeds. The water is relatively clear, enabling marine plants to extend well below the low water mark and for phytoplankton to grow in a photic zone that extends down to 10 m. In the Upper Bay, in contrast, exposed sandstone and siltstone provide an erodible shoreline that yields fine and coarse-grained sediment that is maintained in suspension by tidal and wave forces.

The combination of varied geology, tides, wave exposure and freshwater input generates a wide variety of different habitats over the Bay as a whole. Day and Roff (2000) identified some 32 different habitat combinations – or *seascapes* (cf. Bredin *et al.* 2004) – in the Bay, subsystems that differ in the combination of temperature, exposure, sediment type, slope, stratification,etc.. As a result, environmental conditions and biological communities vary extensively over the Bay of Fundy system in spite of the apparent unity provided by its macrotidal nature (Figures 19 & 20).

The Bay is fundamentally a tide-driven ecosystem. Strong tidal currents result from the near-resonance of the Bay to the natural 12.4 hour forcing of the Atlantic tide, and current velocities exceed 1 m/sec throughout most of the Bay during flood and ebb tides (Jacques Whitford 2008); these velocities are amplified wherever the flow is constrained – as in passages between islands and the entrance to bays. Strong tidal currents entering the Bay encounter rapidly shoaling water depths, creating extensive vertical mixing of deep, cold, nutrient- and plankton-rich water with that at the surface. Recirculation of nutrients results in high primary productivity, and supports diverse pelagic and benthic communities in the Outer Bay. In this region, a food web occurs based on phytoplankton and seaweed exudates, through larger planktonic and free-swimming organisms, to fish and marine mammals. The highly productive regions of the Outer Bay support numerous marine mammals, as well as important commercial fisheries such as for herring, haddock, pollock, lobster and scallop.

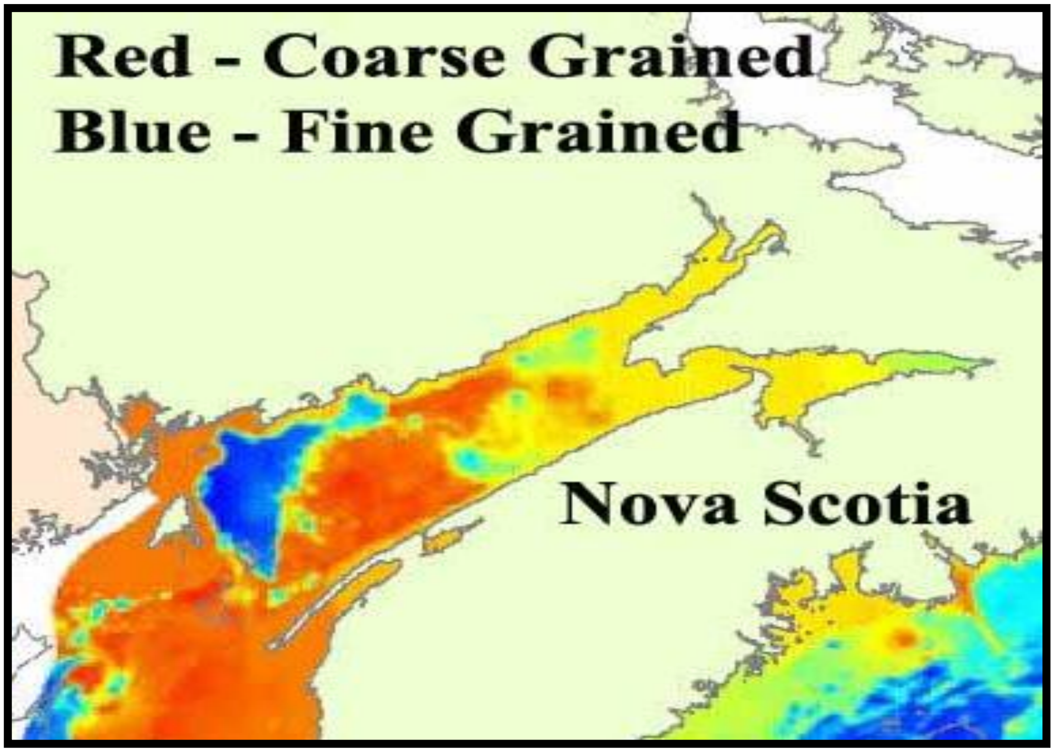
Vertical mixing of the water column is prevalent throughout the Bay, but as the depths decrease and the shorelines become more erodible towards the head of the Bay, turbidity increases, limiting light penetration. As a consequence, although the Upper Bay is also very productive biologically, this productivity is based upon peripheral salt marshes and microscopic plants associated with the extensive intertidal flats that are exposed at low tide. The food web is markedly different from the Outer Bay, being dominated by small benthic organisms such as crustaceans and worms that are extensively preyed upon by resident and migratory fish and migratory shorebirds (AECOM 2011).

The subtidal environment of the Bay varies extensively along its length. Development of new high-precision multibeam bathymetry has enabled much more detailed analysis of the substrate than before, providing an enhanced understanding of the diversity of habitats, their resilience to change, and the close coupling of physical and biological processes (Daborn, 2007; Fader, 2009; Parrott *et al.* 2009). The multibeam bathymetry is a unique data set collected over a 10 year period by the Canadian Hydrographic Service (CHS) and the Geological Association of Canada (GAC). In addition, backscatter data, which can used to map and interpret the surficial geology and benthic habitat, is also available for the entire area. With respect to tidal energy projects, this data can be used for:

- **Initial identification and assessment of potential tidal energy sites;**
- **hydrodynamic modelling for site assessments;**
- **Surficial geological and geomorphological mapping at potential tidal energy sites;**
- **Assessment of benthic habitat when coupled with in-situ data collection; and,**
- **Selection of long-term monitoring sites to assess impacts on benthic ecosystems;**

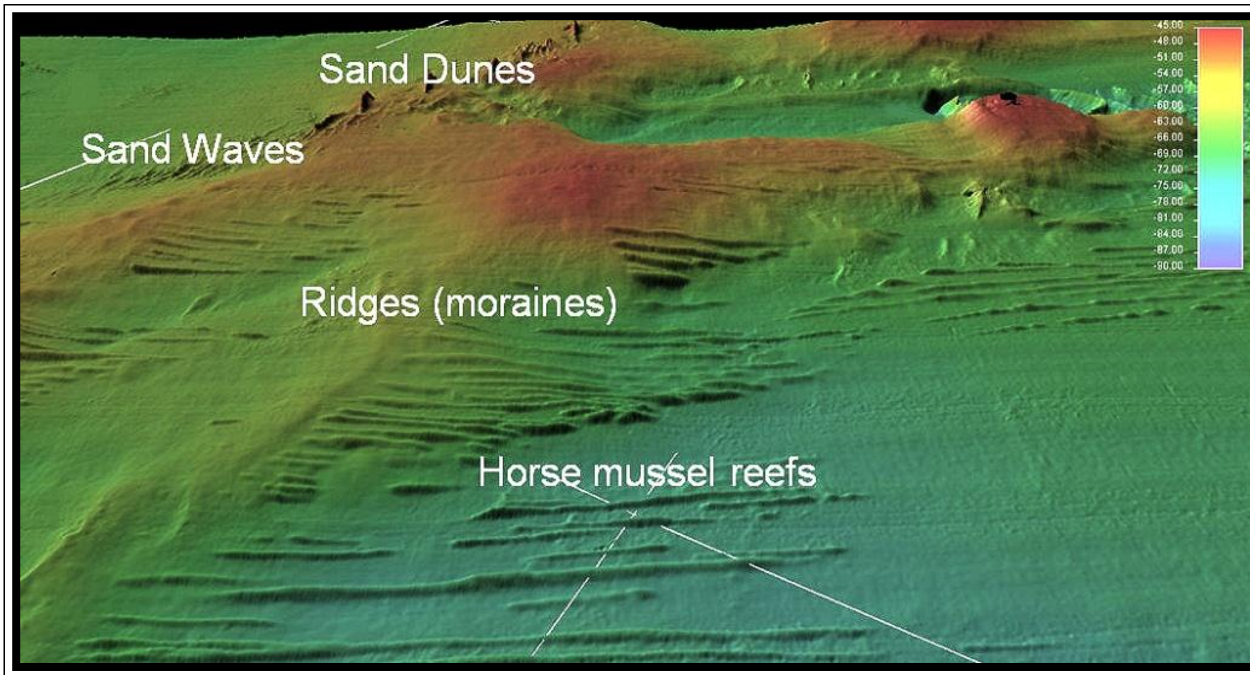
The benthic habitats associated with the varied seascapes give rise to ‘ecologically or biologically significant areas’ (EBSAs) that are considered important for conservation (Doherty and Horsman, 2007; Buzetta and Singh 2008; DFO 2012a; Greenlaw, *et al.* 2012). In the Nova Scotia portion of the Bay of Fundy, 3 distinct areas are recognized as significant EBSAs: the Southern Bight of Minas Basin, Brier Island, and the horse mussel reefs midway between Digby Gut and Cape Split (Figure 35).

Figure 19. Sediments of the Bay of Fundy



(Source: Kostylev and Hannah 2007) Note: Yellow – medium grained.

Figure 20. Multibeam Bathymetric Image of Horse Mussel Reef Field, Outer Bay



(Source: G. Fader) – see Figure 35 for location of Horse Mussel reef area.

Bedrock does outcrop in places, particularly in narrow passages, and if tidal currents are very high (as in Minas Passage), the bottom may be swept clear of sediment and harbour very little life. In less extreme conditions, such as the passages along Digby Neck, however, tidal currents may allow a diverse and abundant benthic community. Much of the bottom of the Outer and Inner Bay is covered with mobile sediments such as gravel, sands and muds that are also strongly influenced by variations in tidal currents. Some areas are relatively stable, whereas others are almost constantly in motion, forming sand waves and dunes, or even gravel waves. Associated with sandy areas are both the important scallop fishing grounds and the unique horse mussel 'reefs' that may extend for kilometers in length. In general, bottom characteristics are controlled by a combination of the underlying geology and the strength of tidal currents (Jacques Whitford 2008; AECOM 2011).

An important feature of the Upper Bay is the presence and variability of ice during winter months. The ice forms primarily in the intertidal zone during low tide, may freeze into the substrate, and then be refloated by the flooding tide. The effect is to rework much of the intertidal sediment during the winter months, creating new habitat for a few species of crustaceans and worms that become the major food source for migratory fish and birds in summer.

Biological diversity is an important concern for conservation and management. The Bay provides heterogeneous habitat that supports more than 2,300 species of benthic and pelagic algae and invertebrates, more than 100 species of fish, scores of bird species and at least a dozen species of marine mammals (AECOM 2011; Gulf of Maine Report 2012). Some of these are considered endangered, threatened or rare and are therefore of conservation concern. More than 20 Bay of Fundy species are listed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) including the North Atlantic Right Whale, Atlantic salmon, Northern bottlenose whale, piping plover, roseate tern and porbeagle shark (AECOM 2011).

It is important to recognize the extent to which physical and biological phenomena in the Bay of Fundy are interlinked, and that these biophysical processes themselves vary extensively through time. In addition to the tides, whose influence varies over hourly, weekly, seasonal and multi-year time frames, the seasonal variations in biological processes, and the influx of numerous migratory species induce a kaleidoscopic change in members of the pelagic community throughout the year and between years. Added to this, however, are the continuing changes in depth of the Bay as a result of post-glacial rebound, increasing tidal range, bottom scouring, and human modifications (e.g. sediment and nutrient additions, dams, dredging activities, etc.). In order to assess the implications of tidal energy development, effects monitoring needs to be carefully designed and the results interpreted against a background of continuous change.

6.2 Recent Tidal Energy Related Research and Monitoring

Environmental monitoring is the periodic recording of information about the state of the environment. Depending on parameter being monitored (i.e., fish, marine mammals, turbulence, bottom scour, etc.), monitoring may occur on a continuous basis, or monthly, seasonally or annually. It serves two different purposes: it can establish baseline information and understanding of natural environmental processes, and it can be used to identify and measure the changes induced by human activity or some external natural forces. In the latter case it is formally referred to as *environmental effects monitoring* (EEM). Environmental monitoring will form a critical element in the assessment of tidal power development in the Bay of Fundy, but will not constitute EEM until there are devices in the water whose effects can be monitored.

The Gulf of Maine Council on the Marine Environment maintains more than 60 monitoring programmes in the Gulf of Maine, many of which extend into the Bay of Fundy (Gulf of Maine Report 2012). These programmes are varied, ranging from contaminants and eutrophication, to aquatic habitats, fisheries, aquaculture, and coastal development. Reports and data may be obtained from www.gulfofmaine.org/esip/index.php. Periodic assessments of important species, either targets of fishery activities or species at risk, are conducted by DFO, and the results published under the Canadian Science Advisory series (CSAS – e.g. Frank 2002; DFO 2009, 2012 a,b,c). Long term monitoring of larval and adult fish populations has been conducted by DFO since 1970 in a grid of stations that includes the Bay of Fundy. The primary purpose of this monitoring is for stock assessment, although the accumulated data are now being examined to understand the long term changes that have taken place in Fundy fish stocks over the last decades (G. Melvin – pers. comm. 2013). So far, no new analyses of this long term data set have apparently been published.

At the present time, most 'monitoring' investigations related to tidal power development in the Bay of Fundy (cf. FORCE 2011) constitute background research aimed at resource assessment, site characterization, and understanding ecological phenomena, rather than true effects monitoring activities (DFO 2012d). This is for three reasons:

- Understanding of natural processes in the Bay of Fundy is still limited, especially in the high flow areas of interest to TISEC development;
- Techniques for monitoring in the very high flows characteristic of the Minas Passage are still under development or assessment; and,
- There are no energy conversion devices in the water at the present time the effects of which could be monitored.

FORCE created an Environmental Effects Monitoring Program (EEMP) as part of the requirements for Environmental Assessment approval. The most recent results (2009 - 2011) are reported on the FORCE website. In 2009, to assist with development and application of the EEMP, FORCE created an independent Environmental Monitoring Advisory Committee (EMAC) to advise on research objectives, study design, and technology to be used, in preparation for an effects monitoring programme to be applied when the test site in Minas Passage receives the next deployment. Under the existing EEMP, the following research studies have been carried out in the vicinity of the FORCE test site (references to data reports are indicted in parentheses):

- Surveys of seabirds and waterfowl using shore-based observers and ships-of-opportunity (Envirosphere 2009a, 2010);
- Surveys of marine mammals using observers and passive acoustic monitoring (Envirosphere 2010; 2012; Tollit *et al.* 2011; Wood *et al.* 2013);
- Occurrence and migration of fishes in the Minas Passage (literature review) (Dadswell 2010);
- Trawl and gill net surveys of fish in Minas Passage (Brylinsky 2010; CEF 2011a);
- Surveys of fish using hydroacoustic techniques (Melvin and Cochrane 2012);
- Monitoring of migratory fish movements and investigations of fish behaviour using acoustic tagging and tracking (Stokesbury *et al.* 2012; Keyser *et al*, 2013; Redden *et al.* 2011; Redden *et al.* 2013);
- Trap-based surveys of lobster in Minas Passage (CEF 2011b);
- Monitoring of lobster movements through the Minas Passage using conventional tags (Dadswell et al. 2009) and acoustic tags (Redden *et al.* 2013);
- Measurements of ambient noise (FEMTO 2010; Martin *et al.* 2012);
- Photographic and video surveys of the seabed in the Minas Passage (Envirosphere 2009c; Envirosphere 2011; Morrison *et al.* 2012); and,
- Continuing investigation of physical oceanographic conditions in the Minas Passage (Envirosphere 2009c; Tao *et al.* 2013).

Funding for these studies has been provided partly by FORCE and partly by the OERA (and under its former name, the Offshore Energy Environmental Research Association – OEER).

The primary research objectives for understanding the critical processes of the Bay of Fundy, and for preparing to assess the environmental effects of tidal power development, have been reviewed several times by researchers, regulators, funding agencies and FORCE. The highest priority has been assigned to the following research questions (in no particular order):

1. **Tidal dynamics**: How much energy can be taken? What are the effects of energy extraction on tidal dynamics and mixing processes both near- and far-field?

2. **Sediments & substrate**: What are the effects of energy extraction and infrastructure on scour (near-field)? What are the effects of energy extraction on sediment deposition or resuspension, both near-field and far-field? What are the effects of energy extraction on shoreline erosion?

3. **Ice & submerged debris**: What are the risks associated with submerged ice & shoreline debris? What are the effects on a) formation & b) movements of sediment-laden ice?

4. **Noise**: What are the intensities and frequencies of ambient noise? How can the noise produced by turbines be distinguished from other (ambient) noises?

5. **Vibrations**: What are the effects of infrastructure vibrations (as distinct from noise) on a) substrate characteristics, b) water column properties?

6. **Electromagnetic field effects**: What are the effects of EMF on fish or other organisms?

7. **Pollution & contaminants:** What are the risks associated with TISEC devices?

8. **Marine mammals**: Can operating TISEC devices be detected by mammals? How and at what distances? What are the direct and indirect risks to marine mammals?

9. **Fish:** Can operating TISEC devices be detected by fish? How and at what distances? Can they be avoided? What are the direct and indirect risks to fish?

10. **Other fauna: plankton, benthos & birds**: Are there direct risks to plankton from passage through a turbine? Are there direct or indirect risks to planktonic forms from a) turbulence, b) noise or vibrations, c) changes in vertical mixing, d) pressure changes, cavitation (etc.)? What are the indirect effects of sediment changes?

11. **Monitoring technologies and instrument moorings**: What technologies are most suited for monitoring currents, turbulence, movements of fish, birds and mammals in the high flow environments in which TISEC devices might be employed? How can these instruments be deployed and how is performance affected by variable flow and bedload transport?

Many of these questions overlap. During the last 5 years, OERA and FORCE have collectively supported research aimed at answering these questions. Certain studies are funded entirely by FORCE while others are funded jointly by FORCE, OERA and Acadia University. The following section briefly summarizes the research activities, many of which are still under way.

In addition to these priorities, DFO is currently working on a Strategic Research Plan for Marine Renewable Energy. The Plan will identify research priorities for offshore wind, wave, and tidal energy projects. The overall objective of the Plan is to develop a strategic science and research plan to address future regulatory information needs related to the granting of project approvals in Canadian marine and freshwater ecosystems (T. Currie, pers. comm. 2013). In support of the Plan, a series of Pathway of Effects diagrams were developed illustrating the potential environmental effects associated with marine renewable energy devices (Isaacman and Daborn 2011). The diagrams were used as the basis for several Canadian Science Advisory Secretariat peer-review workshops that were held in 2011 and 2012 to identify knowledge gaps and research priorities. These diagrams are illustrated in section 7.1.

6.2.1 Tidal Dynamics

Numerical modeling of tidal flows in Minas Passage has been carried out by several research groups. Karsten *et al.* (2011) examined the resource potential of the Minas Passage site, and used their numerical model to investigate the effects of increasing the number of tidal turbines across the passage. Their conclusion is that the total energy in the Passage exceeds 7 GW, of which about 1.4 GW is potentially extractable with only a small impact upon tidal range (a decrease of ~5%) at the head of the Bay of Fundy (Karsten 2013).

Sheng *et al*. (2012) have examined the effect of extracting energy using TISEC devices in Minas Passage on more distant portions of the Bay of Fundy system. Similar to Karsten's modeling results, their results show that if TISEC devices are deployed only in the lower half of the water column, the maximum value of the extractable energy is something less than 2 GW. The effect of removing <7 GW (i.e. extracting over the whole of the water column) would be to increase the surface elevation in the western Gulf of Maine by about 20 cm; if only the lower half of the water column is used, the impact is much smaller. Energy extraction from Minas Passage would have effects on vertical mixing, sea surface temperature, and related ecological features, but these would be minor over the Gulf of Maine and Georges Bank.

A secondary consequence of extracting energy from the Minas Passage could be the effect on wave propagation and shoreline erosion. This was investigated by Martec (2011) using a spectral wave model to simulate wave behaviour with and without tidal turbines. They concluded that an array of 225 commercial-scale turbines in Minas Passage would likely produce small decreases in significant wave height energy at shorelines along the Minas Basin. The effect, combined with slight lowering of the high water level and potential enhanced deposition of sediments in peripheral areas, could be a reduction in wave-induced erosion along the Minas Basin shoreline. At present, modeling accuracy is limited by the paucity of wave climate data in the Minas Basin.

One of the limitations of oceanographic numerical models is that they need to model very large ocean spaces in order to incorporate system-wide oceanographic features such as tides and currents. This often means that small scale processes such as turbulence and device wakes, which are important for assessing near-field environmental effects and device interactions, have to be ignored. Computational fluid dynamics (CFD) models, however, are used widely by turbine developers to explore the near-field effects and operational properties of turbines. A consortium of Canadian researchers was funded by OERA to examine ways to couple oceanographic and CFD models to provide both large scale resource assessment and small scale near-field effects of tidal turbines (Klaptocz *et al.* 2013). The project has developed methods of linkage that can be applied to tidal stream sites at the entrance to an enclosed tidal bay (such as Minas Passage) and sites in inter-island passages (such as Grand or Petit Passage). These techniques are expected to improve both the assessment of resource potential at any given site, and the modeling of near-field effects and array layout.

These modeling projects have significantly advanced scientist's knowledge about the resource potential in the principal areas of interest for tidal development (Minas Passage, Digby Gut, Grand and Petit Passages), and have enhanced the foundations for forecasting the environmental effects of energy extraction. Prior to the 2008 SEA, estimates of extractable energy for Minas Passage were about 300 MW, with no clear understanding of residual effects on tidal dynamics. In contrast, current estimates (Karsten 2013) indicate that energy potential exceeds 7 GW, of which more than 1GW might be extractable with minimal effects on tidal range in the Upper Bay – effects that are less than the natural variation between neap and spring tidal cycles. These improved models are what is required to enable better estimates of both near and far-field effects on hydrodynamics from energy extraction.

6.2.2 Sediments & Substrate

The importance of energy extraction on sediment deposition has been examined by Sheng and his colleagues (Hasegawa *et al.* 2011; Sheng *et al.* (2012); Smith *et al.* (2012) and van Proosdij and O'Laughlan (2013). Smith *et al.* (2012) and Tao *et al.* 2013 analysed ocean colour satellite imagery to examine seasonal changes in surface suspended sediment concentrations in the Minas Basin, providing for the first time a comprehensive account of seasonal variations in suspended sediment concentrations in the Upper Bay system. There is a pronounced peak in concentrations during winter months (January—March), presumably a consequence of ice scouring from tidal flats, but also strong inter-annual differences. In addition, they were able to consider the role of wave action, which varies according to both wind fetch and direction, on the process of resuspension during ice-free months. The results are being used to calibrate hydrodynamic and sedimentological models.

Sheng *et al.* (2012) found that bed shear stress (which is a major determinant of sediment resuspension) in the Minas Passage itself will be significantly changed as a result of energy extraction in the Minas Passage, but the effect on the outer Bay of Fundy and Gulf of Maine is small. In Minas Passage, changes in bed shear stress will have minimal effect on benthic ecology because the bottom is already subject to high stress levels. In more peripheral areas of the Minas Basin, decreases in bed shear stress are likely to result in less resuspension, and consequently to produce localized changes in benthic fauna. Brown *et al.* (2013) have been investigating the potential for multibeam technologies to permit monitoring of the seabed to determine long term responses to energy extraction.

The challenge of forecasting the more distant effects of energy extraction on the sediment regime of the Minas Basin lies in the complex, seasonal variations in biophysical factors determining sediment properties. Van Proosdij and O'Laughlan (2013) investigated the seasonal patterns of sediment deposition and erosion at intertidal sites in the Southern Bight of Minas Basin chosen for their contrasting levels of wave exposure. They used the measured differences in tidal height occurring on spring tides and neap tides to examine the differences in sediment mobility as a proxy for the decrease in tidal elevation expected following tidal energy development. Significant differences in sediment deposition were found in a tidal creek and an exposed mudflat site, and when high water failed to overflow the channel walls, as happens mainly on neap tides, the amount of deposition of sediment was considerably increased. On spring tides, in contrast, water flowing over the channel sides into marshes resulted in increased flows during the ebb tide, causing some remobilization of sediment deposited at high water. One implication is that decreasing tidal range as a consequence of tidal energy extraction could lead to accelerated tendency for tidal channels to fill in anywhere in the Upper Bay or Minas Basin behind a tidal power site.

A complicating factor affecting sediment processes is associated with wave action at the shoreline. Martec (2011) applied the Greenberg hydrodynamic model to assess the effects of energy extraction on local wave climate. Reductions in current velocity and tidal range behind a TISEC array are expected to produce small decreases in significant wave height, some enhancement of sediment deposition along the shore, and therefore slightly moderate the rates of shoreline erosion.

The *in situ* studies of seasonal change in sediment processes in marshes and channels by van Proosdij and O'Laughlan (2013) are the first of their kind in the Minas Basin. Previous sediment dynamics studies have been shorter term, mostly focussed on summer months, and on the open intertidal zone. The results clearly show that sedimentary processes are highly responsive to changes in tidal amplitude, with more sediment accumulation occurring during the smaller neap tides. By implication, therefore, a reduction in tidal range resulting from energy extraction will be expected to favour more rapid infilling of channels in the Minas Basin, even where these are situated a considerable distance away from the tidal energy site. The research needs to be continued to determine whether present or anticipated winter conditions will permit the permanent retention of sediment deposits in the channels, and what the response of marshes will be to a decrease in flood frequency. Similar consequences might be anticipated for the intertidal zone of the Annapolis Basin from energy extraction in Digby Gut, but are less likely to occur in Saint Mary's Bay from turbines in the Digby Neck passages. The results of Sheng *et al*. (2012) indicate that similar effects at greater distances would be immeasurably small.

6.2.3 Ice & Submerged Debris

Sanders *et al* (2008) and some local residents suggest that large blocks of ice formed in Minas Basin in winter contain so much sediment that they become non-buoyant, and therefore may travel below the surface, constituting a hazard for TISEC devices deployed in Minas Passage. This issue would be somewhat unique to the Bay of Fundy, since most other locations (except Alaska) considered for TISEC application do not experience such conditions. The issue has been addressed by Smith et al (2009), Sanderson *et al.* (2012), Black and Hill (2013) and Trowse (2013a). By examining natural ice formed on the shoreline in Minas Basin, Sanderson *et al*. (2013) showed convincingly that in spite of the occasionally large quantities of sediment in some portions of shore-based ice blocks, none of the ice blocks had an overall density that would enable them to leave the shore and travel submersed. Natural ice blocks exhibit very heterogeneous structures, with large void spaces and fractures, and undoubtedly decay very quickly when submersed in sea water at temperatures greater than its freezing point (seawater freezes at -2.5^{o}C). While large ice blocks appear to pose a threat to tidal turbine infrastructure, the likelihood is very low as these would have to closely match the density of seawater in order for them to be entrained into the interior of the water column. Because these structures consist of a combination of ice, air pockets and sediment, Sanderson et al (2012) conclude that they would have to be assembled in just the "right" combinations for a near neutrally-buoyant ice structure to result. In consideration of their structural properties, and the sequence of mechanisms that would be required to create a large, near neutrally-buoyant ice block, the authors conclude that shore-formed, sediment-laden ice blocks do not pose a serious risk to large scale tidal turbines planned for installation in the Minas Passage. Perhaps of greater risk of interaction with turbines are other potential debris, such as logs, lost fishing gear, etc.

Other ice studies recently completed or currently underway at Dalhousie University involve the examination of sediment-laden ice formation and release in tidal creeks, melt rate and acoustic detection (Hill and others). Timing of block formation and block composition were monitored at three tributaries in the upper Bay of Fundy, with samples being collected to assess bulk density and strength (Black and Hill, 2013). Ice block trajectories, based on initial ice mass and water temperature, are being estimated and melt rates of naturally forming and manufactured, sediment-laden ice are being used to develop a melt rate model. The predicted lifetime of a large sediment-laden ice block (about 5,000 kg), using winter temperatures typical of Minas Basin waters, is estimated to be about 5 days in 1°C seawater (Trowse, 2013). The ability to detect ice blocks in the field acoustically is also being examined in a study that employs the use of broadband pulse sonar to detect both manufactured and natural sediment-laden ice formations.

6.2.4 Noise and Vibrations

High tidal flow areas such as those of interest for TISEC deployment are extremely noisy as a result of turbulence, bottom scouring effects, vessel noise, and vibrations of marine infrastructure, etc. Because many marine organisms are sensitive to sound, and some rely upon sounds to receive and relay information, as well as for prey and predator detection, it is important to determine whether the additional sounds generated by operating turbines can be detected by organisms, and whether such sounds will result in a behaviour change that affects the risk of encounter with a device.

Three attempts have been made to measure ambient noise levels at the FORCE site: a) from a vessel using a suspended hydrophone in 2009; b) during the deployment of the OpenHydro device in 2010 using 'drifting ears' technology (Kozak 2011); and c) by Martin *et al.* (2012) using modified high flow moorings. The pre-deployment (a) and the post-deployment (b) studies found that vessel and surface noise contamination prevented discrimination of the sounds generated by the operating OpenHydro turbine from the ambient noise. In 2011 and 2012, autonomous acoustic recorders were deployed attached to high flow moorings by Jasco (2013). In the first deployment, the devices were damaged by local conditions, but excellent data were obtained when deployed with modified high flow moorings in 2012. The results indicate that the signal(s) from an operating turbine should be distinguishable from the ambient noise if a modified high flow mooring is equipped with a pair of hydrophones separated by an acoustically transparent window. The technology is rapidly advancing, and it seems promising that in the near future it will be possible to obtain better monitoring of ambient noise and even to distinguish some mammal vocalizations from the background noise.

6.2.5 Electromagnetic Field Effects

Collins (2012) reviewed the international literature relating to the potential electromagnetic effects associated with underwater cables and MRE devices. Numerous submarine electricity cables have been deployed around the world, many in relation to offshore wind installations. The potential environmental effects have been reviewed many times, and although many organisms are known to respond to EMF, it remains unclear whether it is a significant issue (e.g. EquiMar 2011h).

6.2.6 Marine Mammals

Continued monitoring of marine mammals using land- or ship-based observers occurs at the Minas Passage site (Envirosphere 2012). These observations provide a general account of the presence of marine mammals in the area, but provide no information on their depth of movement and little on their behaviour. In 2010 a series of Passive Acoustic Monitoring (PAM) sensors was deployed during the summer months to monitor the presence of cetaceans (harbour porpoise and/or white-sided dolphins) in the Passage near the OpenHydro turbine (FORCE 2011). PAM sensors record underwater sounds in a frequency range that includes the natural ‘clicks’ produced by echolocating cetaceans, and which are distinctive enough to identify the species producing them. The results confirmed that harbour porpoise are commonly present in the Passage during summer and fall, and that the turbine (which was still deployed but no longer operating at that point) seemed to provide no attractive or deterrent effect on porpoise behaviour (Tollit *et al.* 2011). From May to November 2011-2012, two types of passive acoustic detectors (Chelonia Porpoise Detector – C-POD™ and Ocean Sonics icListen™) were deployed in the vicinity of the FORCE site to record harbour porpoise activity (Wood *et al.* 2013; Porskamp *et al.* 2013). Results confirmed the near year-round presence of porpoises in the test area, with peak activities appearing to be associated with migratory movements of herring and other fishes. Future deployments could provide a sufficient insight into turbine-mammal interactions to enable an effective assessment of risk, in spite of high levels of ambient noise. It is expected that such a study will be carried out when the next turbines are installed at FORCE. There are currently no studies regarding monitoring of marine mammals at the Digby Neck sites.

6.2.7 Fish

Stokesbury *et al.* (2012) and Redden *et al.* (2013) have been monitoring the movements of selected species of fish through the Minas Passage by inserting Vemco™ transmitters into individual fish and recording their location and approximate movements from recordings received at 29 receiver stations arrayed in Minas Passage. The study, which is a collaborative project with the Ocean Tracking Network and Fisheries and Oceans Canada, aims to develop better understanding of where selected species swim (both location and depth) as they transit Minas Passage, by monitoring their frequency of use of the Passage, timing in relation to seasonal, lunar and tidal cycles and their direction and depth of movement. Selected species include: striped bass, the American eel, the Atlantic salmon and the Atlantic sturgeon. Results indicate that individual striped bass may undertake multiple crossings (i.e. moving in and out of the Passage) and both striped bass and sturgeon may swim at depths and locations in the Passage that will coincide with probable depths and locations of TISEC devices. Final reports will be available in mid-2013.

FORCE, through its Environmental Monitoring Advisory Committee, has initiated projects aimed at determining the usefulness of existing commercial weirs for monitoring fish populations within Minas Basin. Aldous *et al*. (2013) conducted a test of the usefulness of shore-based nets to monitor fish remaining in the Basin during winter. Acadia University and FORCE together have also established a monitoring programme to investigate the species captured in fishing weirs in Minas Basin during the summer months (A. Redden, pers. comm. 2013).

6.2.8 Monitoring Technologies

There have been major difficulties associated with monitoring of physical and biological phenomena in the high flow passages of interest to TISEC deployment. These difficulties include:

- Complications with deploying and retrieving recording devices: high current velocities and the high tidal range necessitate use of bottom-moored autonomous devices fitted within subsurface buoys (Broome *et al.*, 2012) or landers (as used at FORCE by Oceans Ltd); acoustic releases sometimes fail, and mooring structures may move or tip over, damaging equipment and / or affecting data collection;
- High turbulence and air bubbles entrained in the water column limit the effectiveness of acoustic monitoring devices, especially near the surface;
- Loss of equipment as a result of burial beneath mobile gravel waves;
- Lack of monitoring technologies designed to operate under such high flow conditions; and,
- Limited battery capacity for recording devices and absence of cable support.

In order to address the need for continuous and reliable environmental monitoring, FORCE is leading a consortium of interests to develop a durable sensor platform that could be deployed for long periods of time (FORCE 2013). Entitled the Fundy Applied Sensor Technology (FAST) Project, the objective is to develop a recoverable cabled platform to which a variety of sensors could be attached. The platform would be deployed and left for several months at a time, and retrieved when sensors need to be serviced or replaced. The monitoring priorities are indicated in Tables 4 and 5:

Table 4. Measurements Required for Site Characterization (modified from FORCE 2013)

Need & Priority	Measurement
1A	Detection/identification of fish and mammals at potential site.
1B	Measure turbulence in the water column.
1C	Measure currents in the water column.
1D	Measure suspended sediments in the water column.
1E	Measure ambient noise (including mammals).
1F	Measure bottom stability.

Table 5. Measurements Required near a Turbine (modified from FORCE 2013)

Need & Priority	Measurement
2A	Detection/identification of fish and mammals in immediate vicinity of a turbine.
2B	Measure turbulence in the water column.
2C	Measure currents in the water column.
2D	Measure suspended sediments in the water column.
2E	Measure ambient and turbine noise.

In addition to developing a reliable, adjustable and removable sensor package that would satisfy needs both of site characterization and environmental effects monitoring, the FAST project offers the opportunity to prove and showcase Canadian developments in monitoring technology.

The descriptions above represent recent work aimed at evaluating the implications of *tidal stream* development. No new work appears to have been conducted to investigate the sedimentary effects of *tidal range* developments, although two proposals for tidal range developments in the Bay of Fundy have been made.

6.3 Socio Economic Environment

The previous SEA (Jacques Whitford 2008) provided assessment of potential impacts of MRE on fisheries, tourism, and workforce. Distilled from these assessments were a set of recommendations that focused on the need to gather information on the economic status of local communities potentially impacted by MRE and the need to understand supply chain opportunities in the renewable energy sector. Since 2008, considerable work has been completed to understand and optimize the social and economic implications of tidal energy development for the province, local communities and the Mi'kmaq (see section 2.11). The sections below describe in general terms the current socio-economic conditions and trends near the Bay of Fundy.

6.3.1 Regional Social and Economic Environment

Population and Coastal Communities

Coastal Bay of Fundy is dotted with small rural communities (*i.e.,* population <1,000, density 2-10 persons/km^2), which make up the majority of the towns within the geographical area (Statistics Canada 2010). Population and demographic trends in these coastal communities are generally reflective of provincial and regional trends. To some extent, increased agglomeration around urban centers caused by economic diversification and restructuring may explain a component of the demographic change in these coastal Bay of Fundy communities (Alasia 2010 and Praxis 2004).

Much of Nova Scotia's population lives in rural areas. A trend of immigration to more central locations of the province and nearer to the capital of Halifax has been observed since 1986 and a decline of 9% in people ages 15 to 24 living in rural areas has been documented (RCIP 2003), the rate of which may be accelerating (Praxis 2004). Despite this decline, Kings, Hants and Colchester Counties, which border the Bay, have experienced a steady increase in population, while the communities of Annapolis, Digby and Parrsboro saw a steady decline between 1986 and 2008 (Statistics Canada 2010 and RCIP 2003). A study examining the population changes of coastal, harbour-centered communities found that changes were community-specific along the Bay of Fundy. The community of Digby Neck, due to changes in fisheries, has experienced the largest decline in population. The shrinking of fishing industries is largely responsible for declining trends in rural areas across the province (Praxis 2004). The regions experiencing population growth support more recently developed industries, such as tourism and recreation. A zone of intensive coastal development exists on the northern portion of the Nova Scotia Fundy shore, while coastal development is sparse in other areas surrounding the Bay of Fundy (Government of Nova Scotia 2009).

Commercial Fishing

The Province of Nova Scotia has a tradition of social and economic links to the marine environment, from the utilization of marine resources by pre-contact Mi'kmaq for 90% of sustenance (MGS 2009), to the fishing communities and related industry, to off-shore oil and gas development, to a leading role in marine research. Nova Scotia's economy and identity is fundamentally connected to the marine environment surrounding the province.

The combined primary fish harvesting and secondary processing industries are Nova Scotia's single biggest source of export earnings. The fishing industry declined significantly during the early 1990s with the collapse of groundfish stocks, but recovered during the second half of the decade. The quantity and value of landings peaked in 2002-2003 but began to decline again after 2003, with significant drops in several species including all groundfish (except haddock), herring, scallop and crab (Gardner Pinfold, 2009).

In general, the Outer Bay supports the largest, most productive commercial fisheries, focused on high value and volume species (*e.g.,* cod, haddock, herring, lobster, scallops) while the Inner Bay supports smaller volume commercial fisheries, with soft-shelled clams, spiny dogfish, flounder, herring, lobster and shad being the species principally exploited. Commercial shellfish fisheries are located in the centre of the Bay and recreational fishing occurs throughout the Bay, but is largely confined to protected embayments, tributaries and tidal passages (Percy 1997; Rulifson *et al*. 2008).

Landings in the Bay of Fundy generally reflect the distribution of most shellfish species, although this is not necessarily the case for finfish, particularly herring. In general, groundfish tend to be landed on the Nova Scotia side, while herring tend to be landed on the New Brunswick side. Fishing efforts for groundfish in the Bay of Fundy have increased in recent years, corresponding to an increase in the concentration of fish abundance and distributions (NSFA 2006). In contrast, stock declines in certain species have resulted in some historically fished species being listed as at risk and their commercial fisheries closed (*i.e.,* porbeagle shark and Inner Bay of Fundy Atlantic salmon; Jacques Whitford 2008).

Fifteen species of invertebrates contribute to Bay of Fundy fisheries. In recent years invertebrate fisheries have surpassed finfish in landed value and are now the most valuable fisheries in the Bay. Unlike many of the commercial fish species, the invertebrate fisheries are mostly based on populations that reside and reproduce in the Bay of Fundy.

American lobster (*Homarus americanus*) is fished commercially in all parts of the Bay of Fundy except the extremely turbid waters of Cobequid Bay and Inner Cumberland Basin, and is caught using baited traps. Most of the Bay of Fundy is limited to a season from late November to July with some winter restriction (AECOM 2009). Fishing grounds expanded during the 1980s and 1990s in the Upper Bay, along the New Brunswick shore, and in the area around Grand Manan Island. Since the late 1970's, a small group of fishers have fished deep waters (to 205 m depth) at the entrance to the Bay of Fundy, targeting seasonal lobster migrations (DFO 1998).

In lobster fishing areas (LFA) 35, 36 and 38, which cover most of the region excluding part of the Outer Bay of Fundy, there are 319 full time licenses, 39 full-time partnership licenses and 7 part-time licenses. Together, these license holders are permitted 2,281 traps (DFO 1998). Landings of this species have been increasing since the 1980s, with landings for the 2005 / 2006 season the highest on record for LFAs 35, 36 and 38 at 3,997 t. Increased landings are the result of favourable environmental conditions in combination with more effective management policies and a decline in predator fish.

Sea scallops (*Placopecten magellanicus*) are fished commercially throughout the Bay of Fundy in six Scallop Production Areas, each with a quota that is divided among the various fleets. There is also a recreational, scuba diving fishery for scallops in the Bay of Fundy, restricted by season, possession limit and minimum size, but there are no statistics on the annual landings from this fishery (AECOM 2009). The scallop fishery in the Bay of Fundy involves three fleets: the All-Bay fleet, the Upper-Bay fleet and the Mid-Bay fleet. The All-Bay fleet has access to the entire Bay, the Upper-Bay fleet may not fish seaward of a line across the Bay through Ile Haute and the Mid-Bay fleet may not fish south of a mid-Bay line running down the Bay from Advocate Head.

The most productive scallop beds in the region are located in the Inner and Upper Bay while other valuable scallop resources are found immediately off the coast of Digby, NS, and around Grand Manan, NB.

Aquaculture

The Bay of Fundy is considered to be Atlantic Canada's primary region for finfish aquaculture, with production in both Nova Scotia and New Brunswick (Jacques Whitford 2008). Salmon is the dominant product of the aquaculture industry in both Nova Scotia and New Brunswick, as measured by the number of producing farms, the total biomass produced and the annual value of the harvest.

Aquaculture in Nova Scotia is diverse, with 18 different species licensed for farming purposes, centered mainly on Atlantic salmon, trout, mussels, oysters and halibut, although Atlantic salmon dominates commercial production values (NSFA 2005). The aquaculture sector started slowly in the early 1980s and expanded rapidly after 1995, achieving a five-fold increase in the value of production. In 2009 the Nova Scotia aquaculture industry reported a $58 million harvest – an increase of 125 percent over the previous 5 years. This number has remained relatively stable since that time; there are currently approximately 200 aquaculture businesses in Nova Scotia employing up to 750 people (AANS 2013).

Most aquaculture in Nova Scotia occurs outside the Bay of Fundy, the exception being a number of lease sites in the Outer Bay of Fundy near the communities of Digby and Weymouth, in the Annapolis Basin and in Saint Mary's Bay, within the Inner Bay of Fundy / Minas Basin in the Avon River and Cobequid Bay areas near the communities of Hanstport and Truro respectively, as well as in Advocate Harbour (Nova Scotia Fisheries and Aquaculture website). There are no aquaculture sites in Minas Passage.

In the past, fish processing was an important source of employment for Nova Scotians, with 7,300 people employed in this industry as recently as 1989. With the collapse of the ground fishery in the 1990's, plant employment decreased to 4,800 in 1996 (Mandale et al. 1998). According to Statistic Canada, the 1996 census data indicate 5,900 people were employed in the fish products industry (excluding wholesale and retail) in Nova Scotia. The Coastal Communities Network's Coastal Resources Database indicates there are 26 fish processing plants located along the Nova Scotia Bay of Fundy with the greatest concentrations centered in the Digby and Yarmouth areas.

A shift in utilization of marine resources away from rural based fishing to urban based technology and systems deployment is reflected in both the population shift and employment rates in Nova Scotia (Canmac Economics Ltd. *et al.* 2006). In an effort to encourage rural retention of workers and promote stabilization of rural populations, the Nova Scotia government has implemented programs such as the Community Development Trust Fund (CDTF – now ended) and Community Economic Development Investment Fund (CEDIF) to re-vitalize rural communities.

Tourism

Tourism makes a significant economic contribution to Nova Scotia's economy, with revenues reaching $1.3 billion in 2004 for Nova Scotia (Jacques Whitford 2008). In 1996, 28,600 people were employed in the tourism industry in Nova Scotia, either on a full-time or part-time basis (Mandale *et al.* 1998). Whale/seabird watching tours made up the largest category of marine tourism operators, with sport fishing and boat tours the second and third largest categories, respectively (Praxis 2004).

7. Environmental Issues

Section Summary

This section provides an overview of the anticipated environmental effects of tidal energy devices, based on projects deployed elsewhere in the world and research conducted in Nova Scotia and elsewhere. A model that shows how potential environmental impacts can be predicted and traced from their origin to their ultimate effect on the environment is described. A series of 12 valued environmental components are described in more detail so that potential impacts and mitigation measures to reduce or eliminate those impacts can be presented.

7.1 Generalized and Anticipated Biophysical Impacts

The literature on the environmental implications of marine renewable energy is somewhat scattered, but rapidly growing. A few comprehensive reviews have appeared in the last five years in Europe and North America, each dealing with more than one MRE type, and based upon relatively few long term deployments of some technologies (e.g. Boehlert and Gill 2010; Isaacman and Lee 2010, Polagye *et al.* 2011). It is evident that the biophysical effects of MRE devices are both site- and technology-specific, and thus understanding is limited by the relatively few deployments that have been in place and monitored for more than a year.

The most extensive empirical knowledge of environmental effects of marine renewable energy relates to offshore wind installations, some of which have been in place for more than a decade. Offshore wind developments share two aspects with tidal stream technologies that provide relevant experience on environmental effects: the presence of similar substructures, such as pilings and gravity bases, and sub-sea electrical transmission cables. Absence of any established lagoon-based tidal installations means that potential environmental effect assessment must be based upon accumulated knowledge of the tidal power stations at La Rance (France) and Annapolis Royal (Nova Scotia), coupled with other studies of coastal barrages and impoundments.

Of the TISEC technologies, research and monitoring studies of a single installed device have been associated with Marine Current Turbines' (MCT) '*SeaGen™'* Tidal System in Strangford Lough, Northern Ireland. This 1.2 MW, twin-propeller device was commissioned in July 2008, and has been generating power into the local grid since December 2008. A continuous programme of environmental monitoring is focused on marine mammals (harbour porpoise and harbour seals), but also includes effects on benthic habitats and organisms (Keenan *et al.* 2011).

Verdant Power has been monitoring the effects on fish of a small array of six 160 KW '*Gen4 KHPS*™' turbines in the East River, New York, since 2006 (Verdant Power 2011). The monitoring programme is being expanded as < 24 additional turbines are deployed to provide an installed capacity of 5 MW (Verdant Power 2010). An extensive environmental monitoring programme was initiated with deployment of a 150 KW *TidGen*™ device in Cobscook Bay, Bay of Fundy, in 2012. Particular attention is being addressed to the behaviour of marine mammals and birds during pile driving activities prior to deployment (ORPC 2012), and to fish in the vicinity of the turbine during testing (ORPC 2013). In the Bay of Fundy, a single 1.2 MW OpenHydro™ device was deployed at the FORCE site in November 2009 and retrieved in December 2010. Monitoring activities included shoreline observations of birds and mammals (Stewart and Lavender 2010) and a few test surveys for fish with nets and acoustic sonar (Brylinsky 2010; FEMTO 2010), but the OpenHydro™ device failed approximately three weeks after deployment, providing very little information on environmental effects.

Pathways of Effects (PoE) logic models describing the anticipated environmental implications of offshore wind, wave, in-stream tidal and in-river hydrokinetic developments have been developed by Isaacman and Daborn (2011). PoE models (Figure 21) are conceptual representations of predicted relationships between human activities (i.e. the *stressors*) and important ecosystem components (i.e. the *receptors*) and their implications for valued ecosystem goods and services. The models recognize that effects may be direct, acting on the organisms themselves, or indirect, resulting from changes in other ecosystem features that result in changes in habitat or in interspecific interrelationships. The PoE models were based upon an extensive review of published studies on the environmental effects of marine renewable energy projects and expert peer evaluation.

Seven environmental changes (*stressors*) have been identified as stressors relevant to tidal power developments (cf. Figure 21):

- Physical alteration of habitat;
- Physical interactions of organisms with infrastructure;
- Changes in ambient light and acoustic regimes;
- Changes in current and wave energy;
- Changes in electrical and magnetic fields;
- Release of contaminants; and,
- Disturbance and/or translocation of fauna.

Four ecosystem component (*receptor)* groups were identified as representing the principal concerns regarding biota associated with tidal power developments:

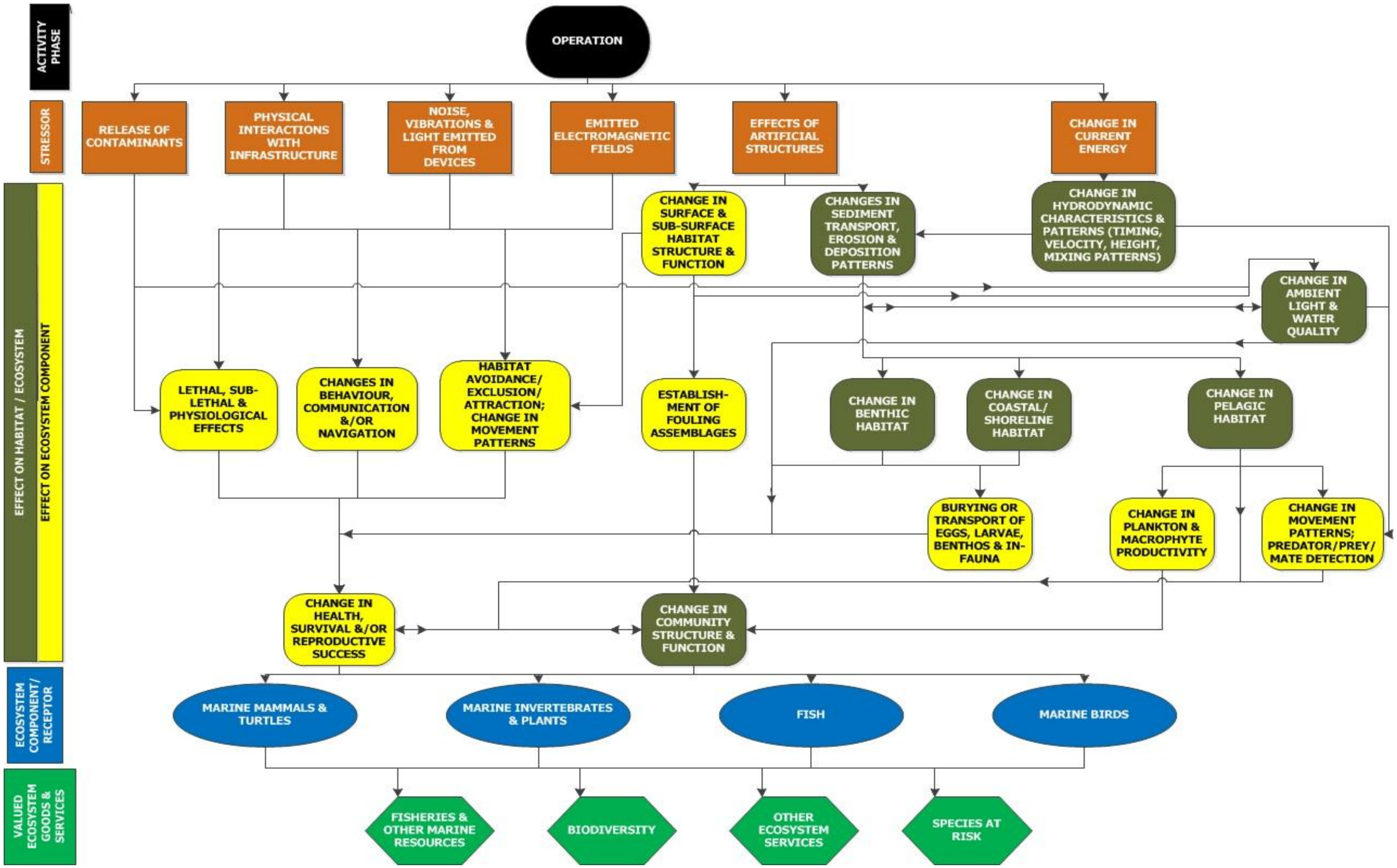
- Marine mammals and turtles;
- Fish;
- Marine birds; and,
- Marine invertebrates and plants.

Pathways of effects logic models were prepared for three phases of development:

- Site investigations;
- Construction, maintenance and decommissioning; and,
- Operation.

An example of the Pathways of Effects logic model for the Operations phase is given in Figure 21.

Figure 21. Pathways of Effects Model for the Operation Phase of Marine Renewable Energy Developments



(Source Isaacman and Daborn 2011)

The consensus from these reviews of potential environmental effects is that, while there may be many areas of uncertainty, the major risks of tidal stream and tidal range-based energy developments are associated with changes in hydrodynamics (flow velocity, turbulence etc.), electromagnetic effects, and the direct and indirect effects of these on marine fish, mammals, birds and turtles. Quantification of these risks is not yet possible because of the few deployments, limited monitoring, and technology-specific features of the tidal devices tested. In the face of this, an ***adaptive management*** approach has been recognized as appropriate by the NSDOE, Fisheries and Oceans Canada, and the US Federal Energy Regulatory Commission (FERC) (Isaacman *et al.* 2012; ORPC 2013). Adaptive management is a process of decision-making that recognizes the need to make decisions where: a) there is considerable uncertainty about the consequences (e.g. to the environment) of the decision; and b) where a development may be undertaken in a staged manner, allowing re-evaluation of the (environmental) risks as the project unfolds. Tidal stream technologies lend themselves to this iterative decision-making approach, but tidal range projects (e.g. lagoons and most shore-based impoundments) may not, because they must be essentially completed before the (environmental) effects can be assessed.

Much of the research effort of the past five years in the Bay of Fundy region has been aimed at answering environmental questions posed in several meetings in 2008, organized by the Fundy Marine Energy Research Network (now FERN: Fundy Energy Research Network), NSDOE and the Offshore Energy Environmental Research Association (now OERA: Offshore Energy Research Association of Nova Scotia), and Fisheries and Oceans Canada (Daborn 2008; Isaacman and Lee 2010). Much, but not all, of the research has been theoretical with respect to biophyscial interactions with turbines, simply because working turbines have not been deployed for long periods in the Bay of Fundy.

Principal funding has been provided by OERA in support of research aimed at the following priority issues:

- Resource assessment for Minas Passage (Karsten *et al*. 2010) and passages in the Outer Bay of Fundy (Trowse *et al*. 2013);
- Effects of energy extraction on sediment dynamics (Smith *et al.* 2012; Sheng *et al.* 2012; van Proosdij and O'Laughlin 2013);
- Effects of energy extraction on wave climate (Martec 2011);
- Effects of sediment-laden ice on TISEC devices (Sanderson *et al.* 2012);
- Effects of TISEC deployments on marine mammals (Tollit *et al.* 2012; Wood *et al.* 2013); and,
- Effects of TISEC deployments on marine fish (Melvin and Cochrane 2012; Stokesbury *et al*. 2012; Redden *et al.* 2013).

Completed reports are posted under Marine Renewable Energy Research Projects on the OERA website.

To a certain degree, MRE projects are similar to other major projects in the marine environment such as bridges or offshore oil drilling platforms. In all cases, marine project activities associated with construction, operation and removal have the potential to impact marine ecosystems and organisms, both at local (near-field) and regional (far-field) scales. The key difference between MRE projects and other projects in the marine environment is that most of the impacts with passive infrastructure projects are associated with construction/installation/decommissioning phases whereas tidal power project impacts are also experienced during the operational phase. With respect to tidal projects, typical issues of concern include changes in physical processes (wave, current and sediment transport regimes), alteration and loss of habitat, contaminants, electromagnetic fields, noise and vibrations and the physical interaction between energy conversion devices and fish, birds, marine mammals and other organisms (Isaacman and Lee 2010).

Table 6 summarizes the potential interactions between MRE projects and the different environmental components of the marine environment. The sections that follow provide more detail on each project component and their typical interactions.

Table 6. Project Phase and Typical Interactions

Project Phase	Physical Process Interaction	Biological Interaction
Seabed Preparation	• Sediment transport during preparation • Waves, currents, mixing & turbulence through obstruction and changes to the seabed shape • Introduction of additional hard substrata • Spills from vessels	• Benthic communities & habitat (organisms that live on the seafloor) • Infauna (organisms that live in sediments) • Fish habitat • Marine mammals
Pile Installation	• Sediment transport (suspension, deposition & scour) • Introduction of additional hard substrata • Noise & vibration • Spills from vessels	• Benthic communities & habitat • Infauna • Fish habitat & behaviour • Marine mammals
Gravity Foundation Installation	• Sediment transport & deposition (suspension and scour) • Introduction of additional hard substrate • Spills from vessels	• Benthic communities & habitat • Fish habitat • Marine mammals
Scour Protection Installation	• Sediment suspension, transport & deposition • Introduction of additional hard substrate	• Benthic communities & habitat • Epifauna • Fish habitat
TISEC/WEC/Wind Turbine Installation	• Waves/currents through obstruction, redirection and induction of mixing & turbulence • Spills from vessels	• Benthic communities & habitat • Fish habitat & behaviour • Marine mammals • Birds
Cable Installation	• Sediment suspension, transport, scour & deposition • Introduction of additional hard substrata	• Benthic communities & habitat • Epifauna • Fish habitat & behaviour • Marine mammal (displacement)
Project Operation	• Waves, currents, mixing & turbulence through obstruction and energy extraction • Alteration of tidal amplitude and lag • Water quality through degradation of antifouling coatings and sacrificial anodes; release of lubricants • Electromagnetic fields • Noise and Vibration • Sediment transport & deposition	• Benthic communities & habitat • Fish habitat & behaviour • Marine mammals • Reduction of downstream nutrients and food supply for benthic filter feeders • Changes to prey types and availability
Maintenance	• Water quality through degradation of antifouling coatings • Waves, currents, mixing & turbulence through obstruction and changes to the seabed shape • Spills from vessels and release of lubricants	• Disruption of marine communities attached to devices • Spill impacts to marine biota, including birds
De-Commissioning	• Sediment transport (suspension, deposition & scour) • Loss of hard surfaces & associated fouling communities • Introductions of discarded materials on seabed • Spills from vessels	• Benthic communities & habitat • Epifauna & infauna • Fish habitat & behaviour • Marine mammals (displacement)

Foundations and Mooring Structures

All existing MRE devices are anchored or moored to the seafloor. The type of foundation used is mainly dependent on the device design, although seabed composition can also influence the foundation type. The Open Hydro TISEC was originally deployed at EMEC on pile foundations and was later redesigned to accommodate a gravity base for deployment in the Bay of Fundy. These two foundation types, the pile foundation and the gravity foundation, are the most common for TISECS.

Piles may be driven into the seafloor if the rocks are soft enough or (at much increased cost) drilled if the bedrock is resistant. The installation of piles in deep water is fairly common, and piles have been used for many years to stabilize offshore drill rigs, bridges and jetties.

A gravity foundation relies on the weight of the foundation itself to keep the MRE device in place on the seafloor. These hollow tubular steel structures are filled with rock or concrete and placed on a level spot on the seafloor. The energy conversion device is mounted on top of the gravity base and is deployed with or following gravity base deployment.

Floating or suspended devices are attached to the seafloor with heavy, corrosion-resistant cables. These cables are typically bolted to the seafloor (a form of pile driving) although a gravity-based anchoring system can also be used.

These physical structures alter the flow of water and can cause scouring of the sea bottom, sediment resuspension and changes to the depositional environment. This in turn may cover and suffocate benthic organisms and fish habitat and disturb or disrupt organisms in the water column such as fish, amphibians and marine mammals. With respect to the noise generated during pile installation, drilling and pile driving, along with the associated vessel traffic, may cause short-term behavioral responses (avoidance), and temporary or permanent hearing damage and fatality to certain fish and marine mammals (Isaacman and Lee 2010). Suspension cables are essentially undetectable to marine mammals. Collisions between marine mammal and cables may injure the mammal and may damage the turbine suspension system.

Seabed Preparation

Seabed preparation refers to dredging or infilling that may be required to create a level surface for the placement of a gravity based foundation. In some cases, a flat but erodible surface may be dredged to bedrock (or at least a more erosion-resistant layer) to provide a stable installation surface.

Both dredging and infilling have similar ecological impacts. Benthic habitat is removed, added or altered, and sediments are re-suspended in the water column where they are washed downstream to be eventually re-deposited, which can potentially alter, damage or destroy existing benthic habitat. The dredging or infilling may result in changes to current and wave patterns, with consequent changes to mixing, turbulence, sediment movement, water column and benthic habitat quality, and coastal erosion. Finally, subsea disposal of dredged material may have further negative consequences on benthic habitat.

Seafloor Scour

Scour is the term used to describe the erosion of the seabed resulting from the installation of a new structure. In the case of a TISEC gravity base, scour occurs as water flows past the foundation and the currents are accelerated in certain locations, causing turbulence and erosion of the sea bed (Jacques Whitford 2008). This sediment erosion tends to undermine the structure and may cause tipping and device destabilization. The eroded sediment may disturb or disrupt species in the water column downstream from the eroding area, while the deposited sediment may destroy or damage marine habitat a considerable distance downstream from the project area.

While scour is not typically a problem when TISEC devices are installed on durable bedrock, scour must be taken into account when planning device deployment in areas of unconsolidated sediments or soft bedrock. Moreover, where scour occurs around the base of a single device, it is likely to be more severe and potentially more problematic when an array of such devices is deployed. The cumulative effect of turbulence from many devices and the resulting severity of scour are difficult to predict and remain recommended research areas (Isaacman and Lee 2010).

Scour effects can be reduced or prevented by a variety of methods, most commonly by the use of protective stone placed around the device foundation. This increases the “footprint” of the project on the seafloor, with consequent effects on more benthic communities and their habitat in the immediate area. Additional impacts include the introduction of new substrate (and consequent increase in habitat diversity) and the additional noise impacts resulting from vessel traffic and protective rock installation.

Cabling

The installation of electrical cabling in marine environments to transmit the electricity generated at offshore wind projects is an established technology. While many of the activities undertaken during cable installation are well known (such as excavation, cable deployment and cable anchoring) and the associated impacts such as scouring have been studied in other industry applications, the impacts of MRE cabling are somewhat unique.

The electrical cable represents a significant part of the project’s capital cost, both in terms of its manufacture and its cost of installation. The cable delivers electricity from the marine facility to shore and may also be used to send and receive operational and monitoring data from the TISEC and nearby monitoring equipment. In addition, cables placed in high current environments may move in response to tidal cycles, abrading the protective covering and allowing seawater into the wiring. Seafloor cables are also exposed to vessel anchors and entanglement with fishing gear. Given its cost, vulnerability to damage and vital importance to the project, cables are typically buried in shallow trenches or laid along rock crevices (if possible) in shallow areas.

It is this trenching and burying process that causes most of the environmental interactions. As may be expected, trenching disrupts benthic habitat and releases suspended sediment to drift with the current, potentially smothering nearby habitats. The clouds of suspended sediment may temporarily disturb fish, shellfish and marine mammals in the vicinity. The cable itself, if installed in a high current environment, may increase local scour, destabilize bottom sediments and cause erosion over a considerable period of time. If laid on the surface of unconsolidated sediments, the cable provides a substratum for the attachment and protection marine organisms that would not otherwise be found in this habitat.

Both alternating current (AC) and direct current (DC) cables create electromagnetic fields (EMF) when electricity flows through them. The electric current induces a magnetic field in the immediate vicinity that is proportional in extent and strength to the magnitude of the current. These magnetic fields, in turn, can result in secondary electrical fields when organisms move through the magnetic field (USDOE 2009b). Considerable research has been conducted on submarine cables conveying electricity from such activities as inter-land power transmission, offshore oil and gas installations, and offshore wind farms (etc.), but little in specific relation to TISEC generation. Environmental effects vary according to the nature (AC vs. DC) and voltage of the current flow, the cable shielding, and the species that are prevalent in the area. Gill *et al.* (2005) in their review of the technical literature regarding the effects of EMF on marine organisms concluded that significant knowledge gaps remain on this subject. They noted that cable networks, such as those that would be installed at tidal arrays, would likely have overlapping and potential cumulative effects. Cable burial is proposed as the most effective way to shield marine organisms from EMF effects (CMACS 2003). In regard to the Minas Passage site, although sensitive species such as sharks, rays and skates are present, it is not yet known how close they swim to the bottom when in the Passage, and whether they would remain in the vicinity of the cable once it is laid. If the Passage is primarily used for transit between the Minas Basin and main Bay of Fundy, the EMF risk is likely to be small.

Turbine Maintenance

Tidal turbine maintenance consists of performing a variety of periodic repairs to above water or submerged structures. These activities include removing attached organisms, lubricating moving parts, repainting structures, and carrying out needed repairs. Maintenance activities will result in temporary impacts similar to those that occur when the units are installed, such as increased vessel traffic, increased noise, increased risk of hydrocarbon spills and disturbance to marine life (Polagye *et al.* 2010). Maintenance activities may affect marine habitats and organisms periodically, but the effects are likely to be short lived.

For TISECs, more significant repairs, such as the replacements of gear boxes or blades may require returning the component or the entire device back to shore. It is not clear how often this type of maintenance would be required, however device design life is on the order of 20-25 years (Li and Florig 2005). Given that TISEC technology remains at a relatively early stage in its development, it is likely that initial deployments of TISEC devices in the Bay of Fundy would require more frequent inspections and maintenance than the final large-scale commercial installations (Jacques Whitford 2008).

Exclusion and Safety Zones

This subject is presented in Section 10.0 Area Use Conflict Mitigation.

7.2 Critical Physical Processes

7.2.1 Definition and Rationale for Physical Process Selection

The major physical processes that define the Bay of Fundy and determine its ecological characteristics involve water movements, sediment dynamics and ice formation. Any significant modification of these processes may have ramifying effects upon both the ecology of the Bay and the economic activities that are associated with it. For example: reductions in current velocity affect turbulence, mixing of fresh and saline water, and the transport and deposition of sediments; changes in turbulence affect water clarity and primary production; sediment properties (especially grain size, cohesiveness, organic and contaminant contents, weathering of surfaces, etc.) determine the benthic organisms that inhabit them, and consequently affect the fish and other species that feed upon benthic and pelagic organisms. For this reason, the potential effects of energy extraction devices on physical processes constitute a key environmental issue.

Water movements of concern include:

- Tidal currents – these affect the exchange of materials (nutrients, contaminants, oxygen, etc.) in estuaries, determine the erosion, resuspension and deposition of sediments, and are the principal reason for interest in tidal energy extraction; and,

- Vertical mixing processes – especially areas of stratification or upwelling that are important in determining the nature of biological production both in the water column and on the bottom.

The relationship between current flow and sediment dynamics is complex. Non-cohesive sediments, such as sand and gravel, respond strongly to current velocity of the water, and their deposition or resuspension can be described with numerical models. The particles of finer sediments, however, such as clays and silts, are more likely to stick together, and this cohesive nature may vary according to their water content or the presence of organic compounds released from microscopic algae (Faas *et al.* 1992; Daborn *et al.* 1993). The behaviour of cohesive sediments has proved much more difficult to model. Sediments become an issue in four ways:

- When settled on the bottom, they are a major factor determining the community of animals and plants that inhabit them;
- Both in suspension and when deposited, they may carry contaminants that are available for uptake by pelagic and benthic organisms;
- In suspended and deposited mode, fine sediments are potentially the 'food' for many invertebrate suspension feeders that strip the bacteria and organic matter present on the particles; and,
- In suspension, they may affect the behaviour and/or health of animals by their effects on gills or visibility of the water column.

Ice has important physical effects on currents, waves, sediments and biota, particularly in the Upper Bay. This is of relatively little consequence in the Outer Bay of Fundy, but may be significant in the Minas Basin, where it may be responsible, in part, for reworking of sediment during the winter months (Daborn 2007; Wu *et al.* 2011; Smith *et al.* 2012).

7.2.2 Potential Environmental Interactions

The environmental implications of changing critical physical processes associated with tidal flows are outlined in detail in the previous Strategic Environmental Assessment Background document (Jacques Whitford 2008). Environmental changes resulting from tidal power developments vary significantly between *tidal stream* and *tidal range* approaches. Extracting energy from flowing water using TISEC devices has a complex effect on tidal flow characteristics: any structure (e.g. the support structure of a turbine) placed in the marine environment tends to resist flow, causing an acceleration of water around the obstruction. This local effect may induce scour and modify the nearby benthic habitat. Operation of the turbine removes energy from the flow downstream of the device, which means that flowing water is less capable of carrying as much sediment in suspension. Consequently, among the effects of extracting tidal energy are:

- A decrease in the resuspension of sediments and/or an increase in sediment deposition in areas where the flow is less;
- Changes in conditions determining settlement of marine larvae;
- A decrease in food supply to benthic filter feeders; and,
- A decrease in turbidity and hence an increase in potential light penetration, affecting primary productivity.

These effects apply both to arrays of tidal stream turbines and to lagoons, and will generally be proportional to the degree of energy extraction. In addition, enhanced sediment deposition and increased light penetration are expected to be particularly notable in lagoon impoundments, resulting in a substantial shift in community composition and diversity behind the barrier.

As more turbines are deployed in a tidal channel, the total resistance to flow results in an increase in water level difference between the seaward and landward portions of the channel (i.e. raises the tide *head*), increasing flow rates and the energy density of the water up to a point beyond which friction losses become so great that the flow begins to decline. This point represents the maximum extractable energy theoretically available, but not necessarily that which is realistically extractable (Karsten 2013).

The above considerations are the basis for extensive research into resource assessments and hydrodynamic and sediment modeling during the last five years, as described in section 5.2 above.

A complicating factor affecting sediment processes is associated with wave action at the shoreline. Martec (2011) applied the Greenberg hydrodynamic model to assess the effects of energy extraction on local wave climate. Reductions in current velocity and tidal range behind a TISEC array are expected to produce small decreases in wave height and some enhancement of sediment deposition along the shore. This additional deposition is in turn expected to lower the rates of shoreline erosion.

7.2.3 Environmental Planning and Management Considerations

Studies suggest that removing energy from confined tidal streams, especially those in relatively low energy channels, may cause more profound hydrodynamic and ecological effects than extracting energy from high energy, open ocean systems (Black and Veatch 2005; Neill *et al.* 2009; Neill *et al.* 2011). This is because in low energy channels the proportional effect of realistic energy conversion is relatively greater than it would be in high energy systems. It is much more likely, for example, to produce a significant change in sediment deposition or resuspension in a lower energy system because the rates of flow are closer to critical shear velocities that determine sediment transport or settling, than in a high energy passage where current velocities far exceed those critical shear velocities. Similarly, the effects of turbine-generated turbulence on boundary layer thickness and stability will be greater in a lower energy system.

Localized scour and downstream redistribution of sediments may be expected on all types of bottom substrata except exposed bedrock. These effects will occur during project installation and possibly during TISEC operation. Sediment may accumulate in the shelter of operational TISEC devices at all locations. None of the potential development sites appear to experience high turbidity (elevated suspended sediment concentrations) on a regular basis; so any localized sediment resuspension would likely have observable, but temporary effects on marine organisms in the immediate area.

7.3 Fisheries and Aquaculture

7.3.1 Definition and Rationale for Selection

Marine fisheries have been a major industry in the Nova Scotia portion of the Bay of Fundy for centuries. More than 100 species of finfish are known from the Bay. Commercial fisheries target more than 30 species of finfish, 12 invertebrate species, and three types of algae (Jacques Whitford 2008), all of which occur within the Nova Scotia portion of the Bay. In addition, recreational fisheries are based upon a dozen fish and four invertebrate species.

Commercial harvesting takes place using a variety of techniques, either with **mobile gear** (e.g. bottom and mid-water trawls, drags, seines, drift nets and longlines), or **fixed gear** (e.g. traps, bottom-mounted gill nets, and weirs). All of these techniques are used in the Nova Scotia portion of the Bay of Fundy, but the extent to which they each are used varies between the Upper, Inner and Outer regions of the Bay.

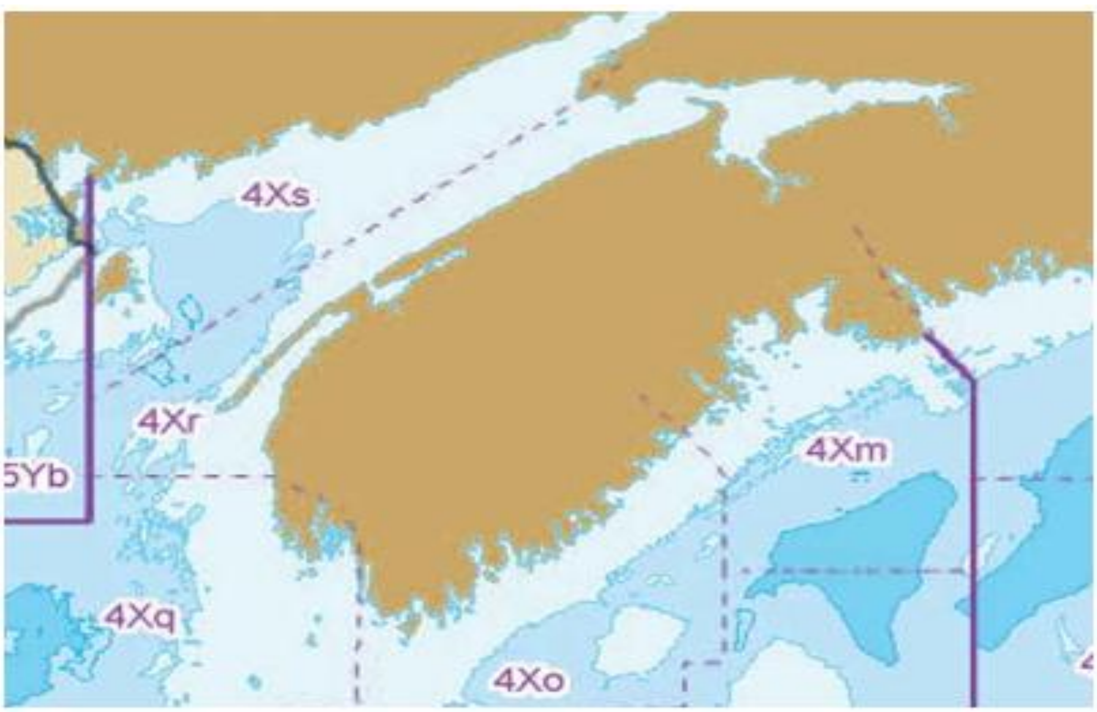
Trawling (or dragging), longlining and handlining for groundfish by larger vessels (> 19 m) are primarily activities of the Outer Bay and Gulf of Maine, and relatively few large vessels harvest in the shallower waters of the Upper Bay or the inter-island passages (Kenchington *et al.* 1994). Principal species of interest are cod, halibut, haddock, hake, and pollock (etc.), but numerous other species are taken, especially by trawls, which are less selective of the species than lines with hooks.

Scallop dragging is a Bay-wide activity, but tends to be concentrated in deeper waters rather than inshore, and thus is less likely to interact directly with tidal energy activities. Bottom and mid-water trawling by smaller vessels occurs in shallower regions throughout the Bay, particularly in pursuit of flounder, skate and dogfish. Pelagic fish species, especially herring, shad and pollock, are captured by a variety of techniques, including mid-water trawls, gillnets and intertidal weirs. These fisheries are widespread throughout the Bay, although weir fisheries in Nova Scotia waters appear to have been reduced to a few sites in the Upper Bay in recent decades[10].

Lobsters and crabs are taken primarily in traps. The lobster fishery is a Bay-wide activity that includes both deep and shallow waters, including the high energy passages between islands and the entrance to bays. Crab fishing is mainly concentrated in the Outer Bay. The potential for tidal power installations to interact with these important fisheries varies considerably. Potential risks to the fisheries are described below.

Management of commercial fisheries in the Bay of Fundy is complex. Licensing and reporting are basically species-specific, with either individual or fleet-wide Total Allowable Catch (TAC) allotments. Catches are recorded primarily in relation to the point of landing, and not where the fish are actually taken. For most species, the data recorded by DFO are related to the overall Management Area rather than to the specific location with the Bay that the fish are caught. For this reason and for most species, it is not really possible to demonstrate the precise location(s) in which capture takes place. This makes it difficult to determine precisely what risk tidal power development may present to a given commercial fishery. Most pelagic and groundfish landings in the Nova Scotia portion of the Bay of Fundy are recorded according to the North Atlantic Fishing Organization (NAFO) Fishing Areas 4Xr and 4Xq (Figure 22). NAFO Area 4Xq extends well beyond the boundary of the present SEA study area, and therefore includes fish stocks that are remote from the potential development of tidal power.

Figure 22. NAFO Fishing Areas of the Bay of Fundy

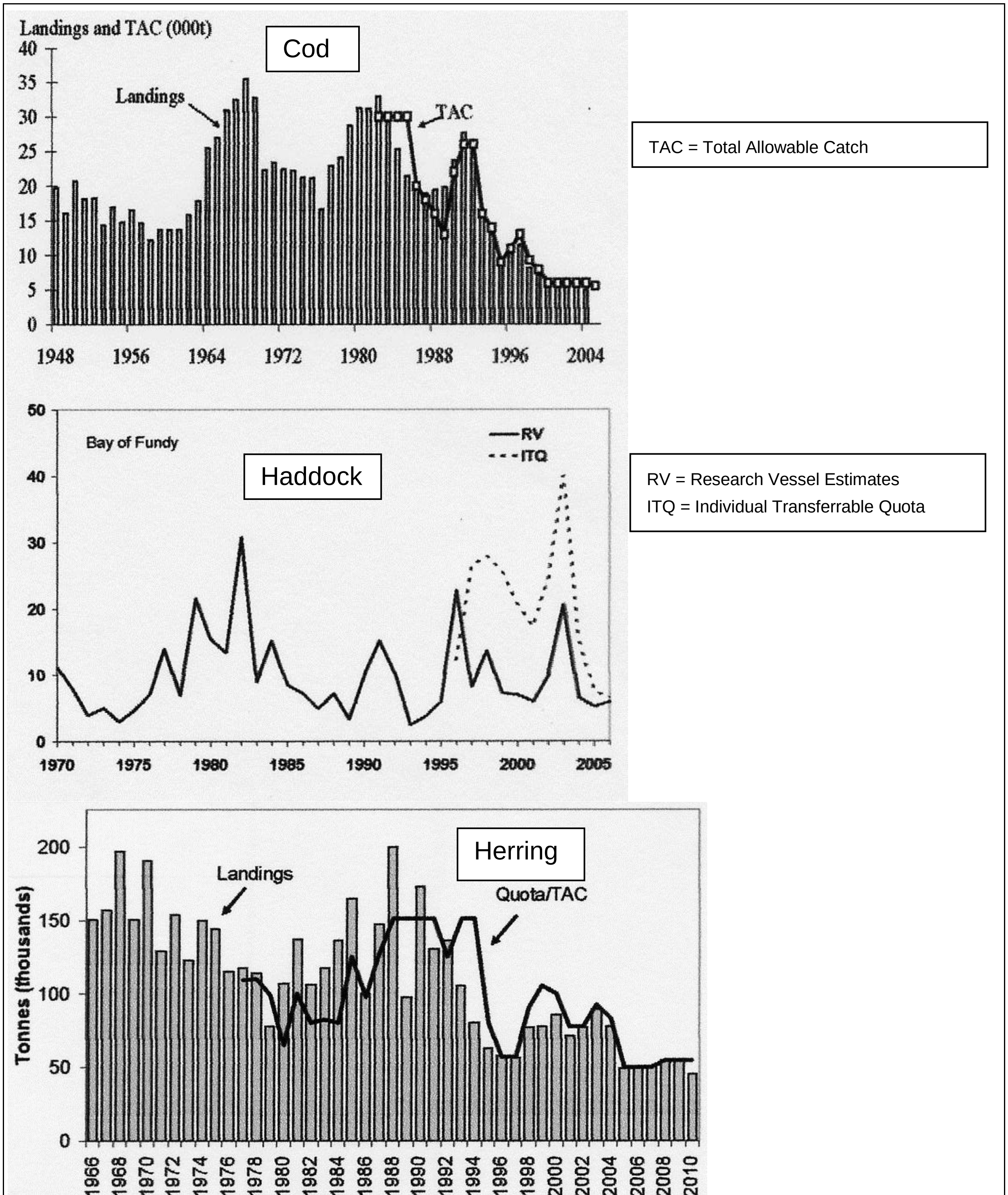


Source: Courtesy of DFO Oceans Management

[10] *http://www.digbycourier.ca/Business/2013-07-16/article-3317047/No-weirs-on-Digby-Neck-this-year*

Stocks of all major groundfish species in the Bay of Fundy have fluctuated considerably over recent decades, but most have been at relatively low numbers in recent years (Figure 23).

Figure 23. Landings of Cod, Haddock and Herring in Fishing Areas including the Bay of Fundy

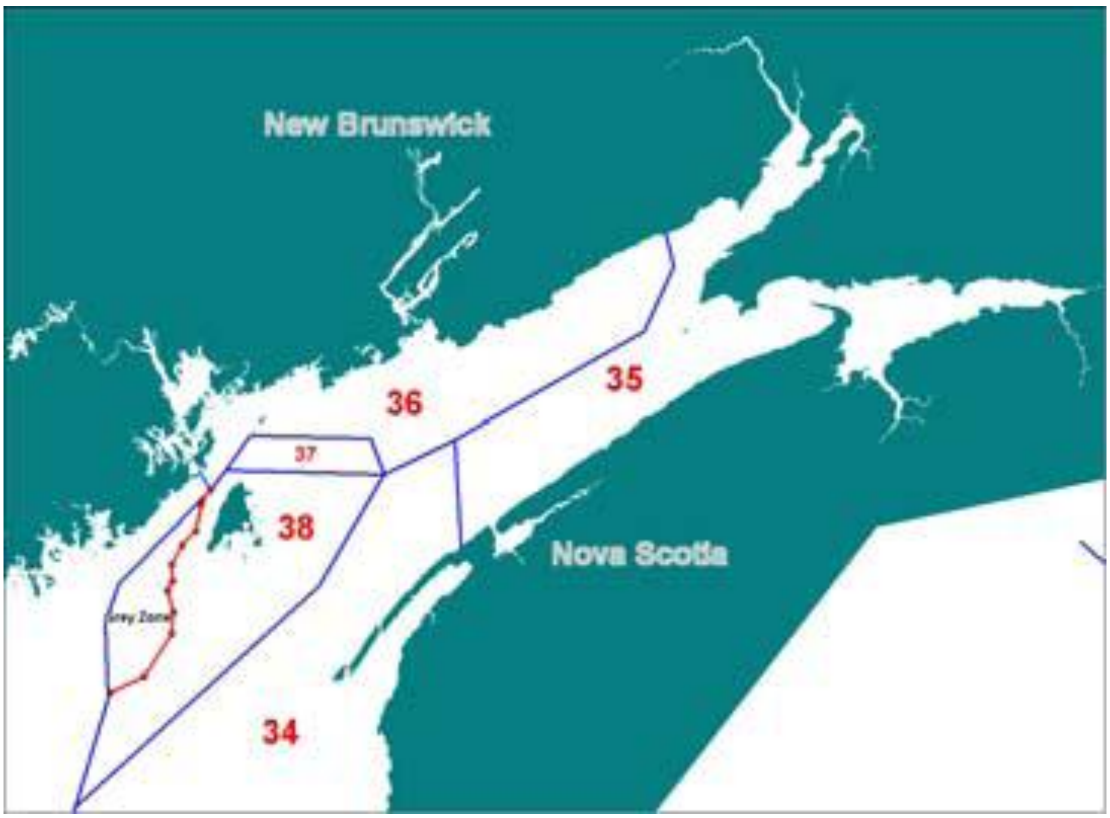


Source: Courtesy of DFO Oceans Management

Shellfish fisheries such as lobster and scallop now represent the greatest commercial value, and are pursued extensively throughout the study area, providing major employment and revenue generation to Nova Scotia (DFO 2012b).

The lobster fishery in the Bay of Fundy is a co-managed activity operating mostly through small vessels landing at numerous harbours throughout the Bay. Regulation is by 'input control' rather than TAC: fishing effort of vessels is limited by season and the number of traps that may be set. The present SEA study area is covered by Lobster Fishing Areas (LFA) 34 and 35, both of which extend to regions of the Bay and Gulf of Maine that are outside the Study Area (Figure 24).

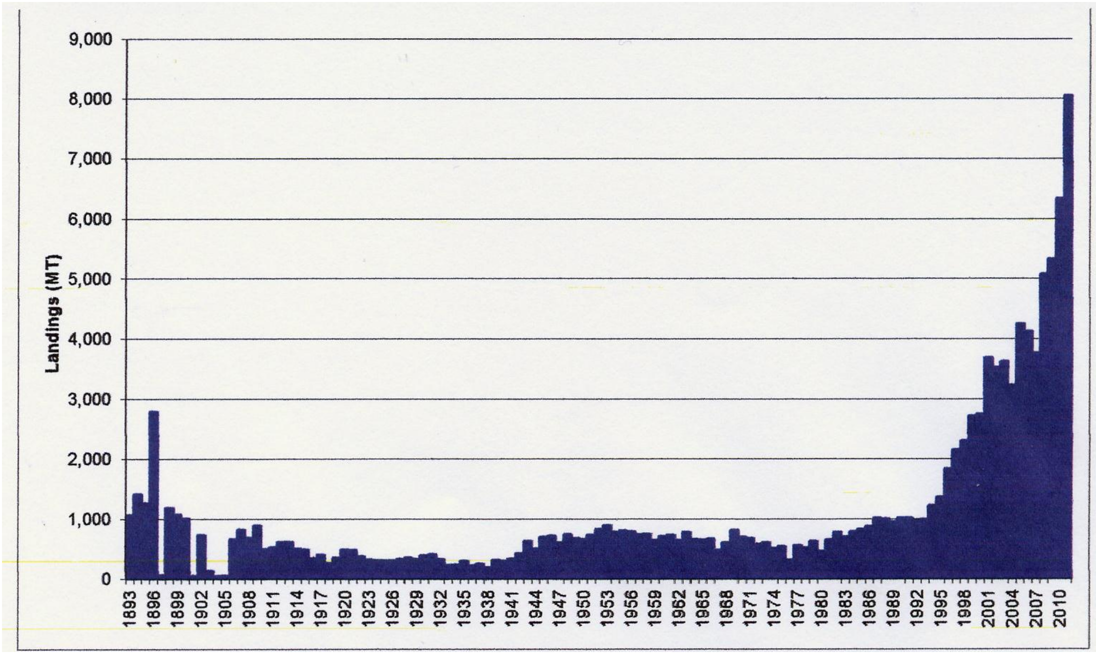
Figure 24. Lobster Fishing Areas, Bay of Fundy



Source: DFO 2007 (CSAS 2007/037)

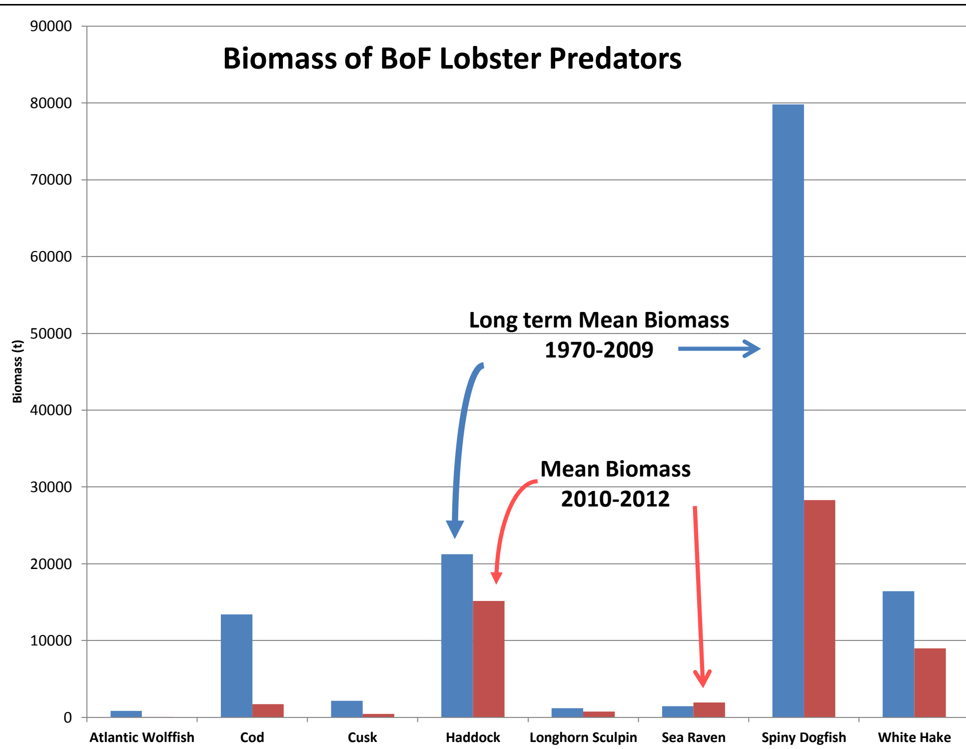
Lobster landings in the Bay of Fundy area have increased significantly in recent decades (Figure 25), partly because of an increase in the number of days fished and the number of trap hauls (DFO 2013), as well as the movement of the fishery into high flow areas such as the Minas Passage and Channel. Another factor, however, may be the decline in major lobster predators indicated by annual summer biomass records: biomass values for the major fish predators indicate that most species (except sea raven) are well below their historic average values (Figure 26).

Figure 25. Annual Lobster Landings in LFAs 35-38, 1893 to 2011.



Source: CSAS 2013/023

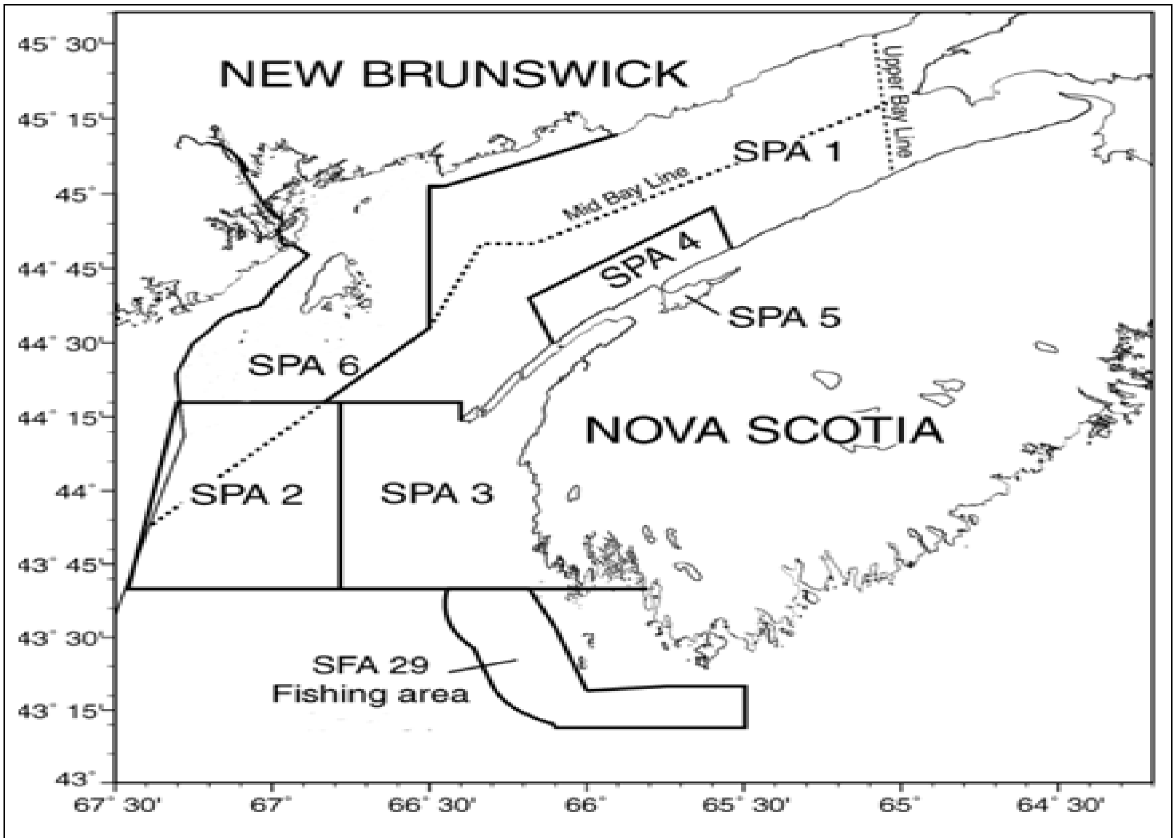
Figure 26. Changes in Biomass of Major Lobster Predators, Bay of Fundy (BoF), 1970-2012



Source: Modified from: DFO 2013

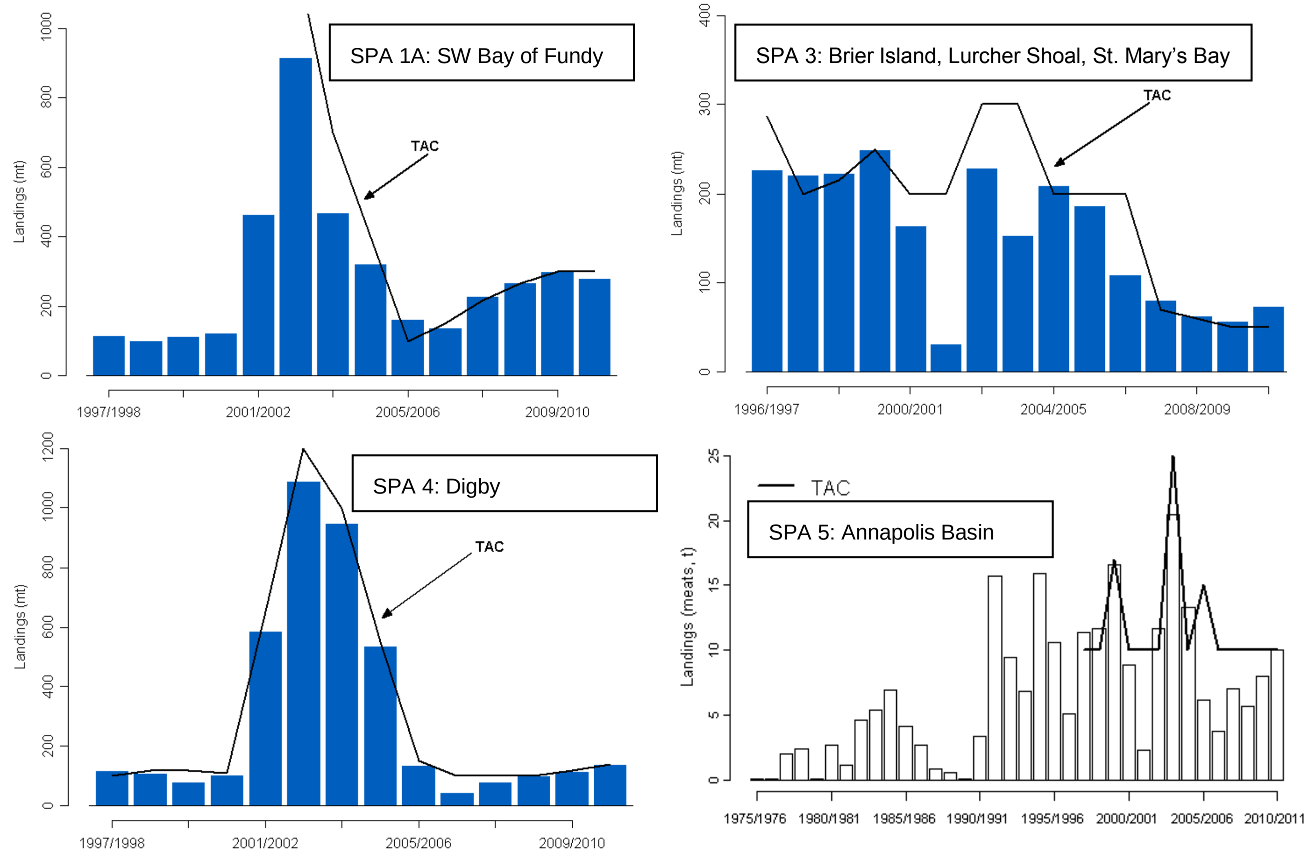
The Bay of Fundy is included within a single Scallop Fishing Area (SFA 28), that is in turn divided into six Scallop Production Areas (SPAs) (Figure 27). The fishery is pursued by three recognized fleets: a Full Bay fleet consisting of vessels 45 to 60 feet in length, in which more than one vessel may be owned by corporations; and two other fleets (Mid-Bay and Upper Bay) that consist of smaller owner-operated vessels. Management is conducted on the basis of a Total Allowable Catch for the whole Bay (1070 tonnes for 2012), which is then subdivided. Members of the Full Bay Fleet are assigned individual transferable quotas (ITQs) based upon established percentage shares of the fleet's TAC by license, whereas the Mid- and Upper Bay fleets have a fleet TAC that is then fished competitively.

Figure 27. Scallop Production Areas in the Bay of Fundy



Source: DFO 2012b.

Figure 28. Scallop Landings (meat by tonne), Bay of Fundy (excluding Upper Bay landings)



Source: DFO 2012b

Commercial fisheries for softshell clams (*Mya arenaria*) and for baitworms (mostly *Glycera* sp.) previously were important in intertidal areas, especially St. Marys Bay, Annapolis Basin and Minas Basin, but these have declined in scale in recent years. Softshell clams are still subject to recreational harvesting, although access is often limited by health restrictions related to sewage pollution or shellfish toxins. The baitworm fishery has declined mainly because of overharvesting.

Several species of fish and shellfish are taken by recreational fishers in tributaries and coastal waters in the Bay of Fundy. There is no federal licensing programme in place for recreational fisheries, but since 2002 DFO has applied controls through quota and size limits, and through limited seasons for recreational fish species such as mackerel, flounder, smelt, eel, shad, gaspereau, and striped bass. Recreational fisheries are pursued mostly near shore or in rivers, including areas that might be used for tidal energy generation. Management of estuarine and river fisheries in Nova Scotia is through six Recreational Fishing Areas, three of which include the counties bordering the Bay of Fundy.

In recent decades, aquaculture has also become an extremely important industry, eclipsing many of the finfish stocks in yield and value. Most of the aquaculture activity in the Bay has been developed on the New Brunswick side, but aquaculture in Nova Scotia waters is diverse, with 18 different species licensed for farming purposes, concentred mainly on Atlantic salmon, trout, mussels, oysters and halibut. Salmon is the dominant product of the aquaculture industry in Nova Scotia, as measured by the number of producing farms, the total biomass produced and the annual value of the harvest.

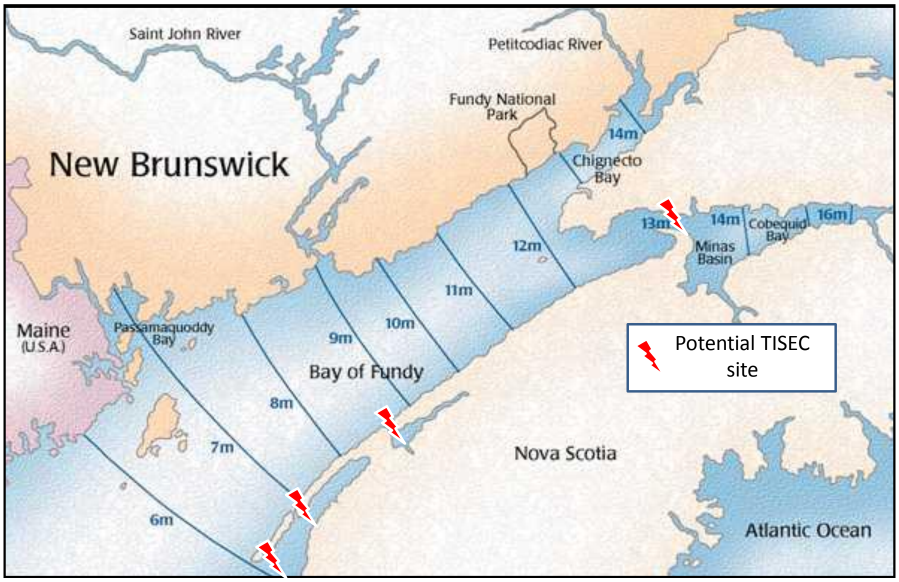
Most aquaculture in Nova Scotia occurs outside the Bay of Fundy, the exception being a number of lease sites in the Outer Bay near Digby and Weymouth, in the Annapolis Basin and in St. Marys Bay, within the Inner Bay in the Avon River and Cobequid Bay near Hantsport and Truro, respectively, as well as in Advocate Harbour (NSFA website). Kelly Cove Salmon Ltd. operates two large farms in the Digby area, one at Freeport and one at Grand Passage.

Implications of Tidal Energy Development for Fisheries

Because of the widespread fishing activities throughout the Bay, their importance to regional and local economies, and the fact that a number of species migrate into the Bay from many parts of the Atlantic Ocean, fisheries are an important consideration for sustainable marine energy development. Effects on fisheries of tidal power development may be both direct (e.g. because of safety exclusion zones, effects on fish behaviour, direct mortality, etc.) or indirect (e.g. through effects on habitat conditions, prey or predator abundance, etc.). All parts of the Bay system harbour some important fishery, but because of the highly variable physical and habitat conditions throughout the Bay, the effects on fisheries are to a considerable extent site-specific. Consequently, the summary below can only describe the more general implications of tidal power development. A full assessment of risk to fisheries undertaken for specific projects will need to take into consideration the varied circumstances found in different portions of the Bay.

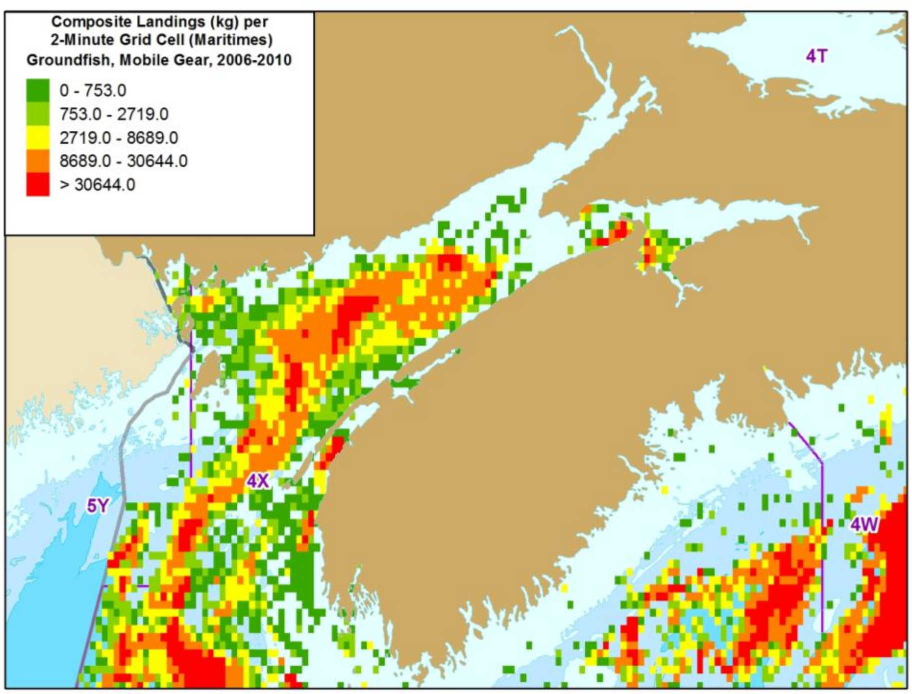
Since tidal energy generating devices are most likely to be installed in high flow areas such as the inter-island passages along Digby Neck and the entrances to Minas and Annapolis Basins, direct interaction is expected to be limited for most forms of commercial fishing. The exceptions are lobster and crab trapping areas, some inshore scallop dragging areas, and shore-based recreational fisheries. Figure 29 – 34 illustrate at a very general level the potential for TISEC-Fisheries interactions. Near shore aquaculture operations also have the potential to interact with small scale tidal energy developments, although aquaculture operations are not typically installed in the high current environments that host tidal energy developments.

Figure 29. Possible TISEC Project Locations



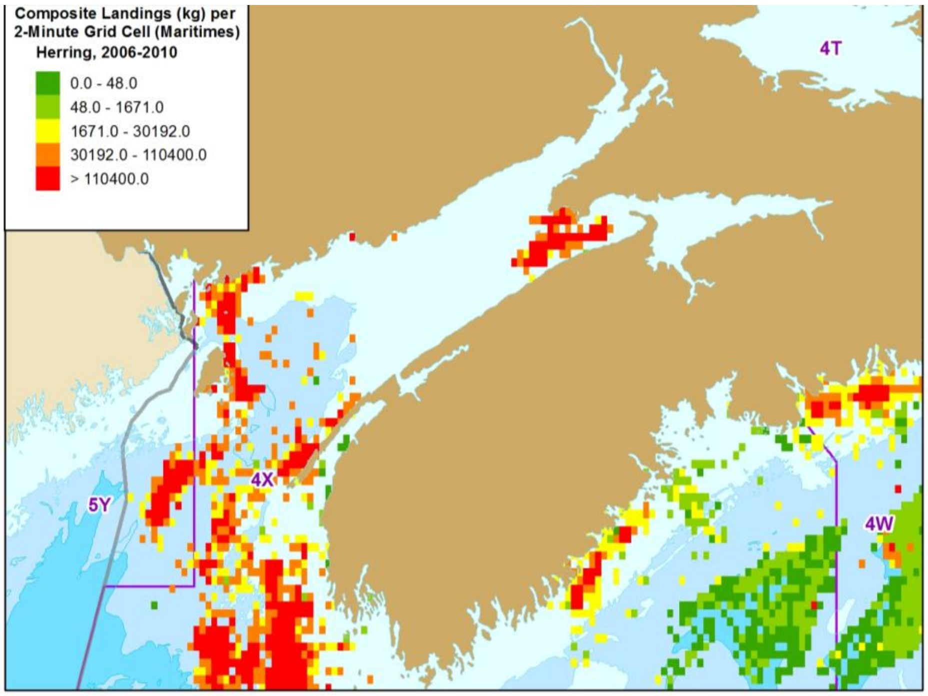
Note: the lines connecting Nova Scotia to New Brunswick represent approximate tidal ranges at those locations.

Figure 30. Groundfish Landings by Mobile Gear 2006-2010



Source: Courtesy of DFO Oceans and Coastal Management Division (5-year composites (2006–2010) of catch weight (kg) per 2-minute grid cell).

Figure 31. Herring Landings 2006-2010

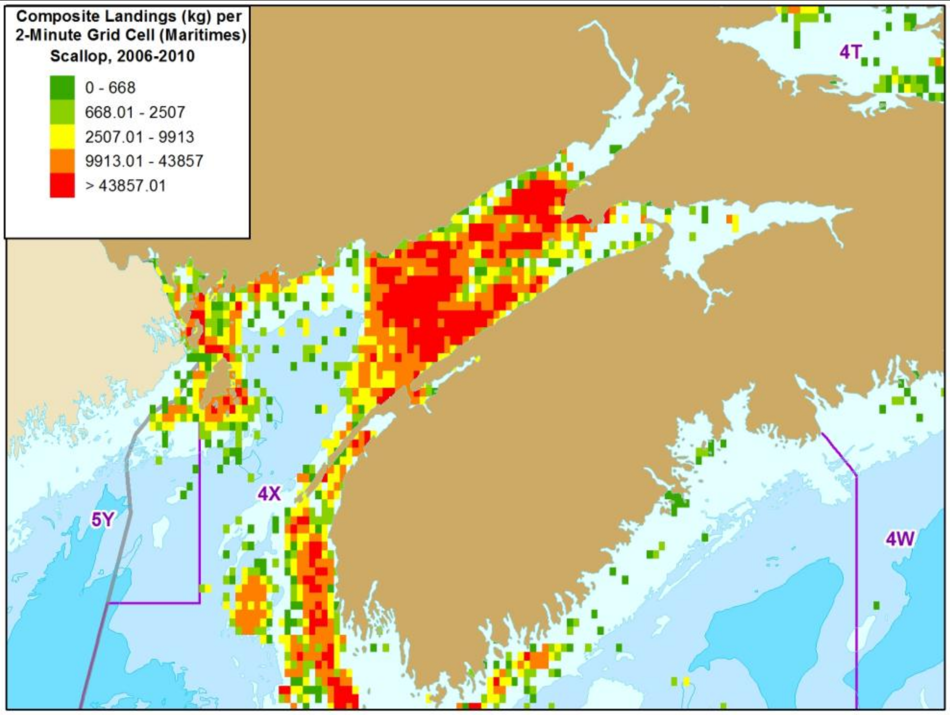


Source: Courtesy of DFO Oceans and Coastal Management Division (5-year composites (2006–2010) of catch weight (kg) per 2-minute grid cell).

Figure 32. Lobster Harvest Areas

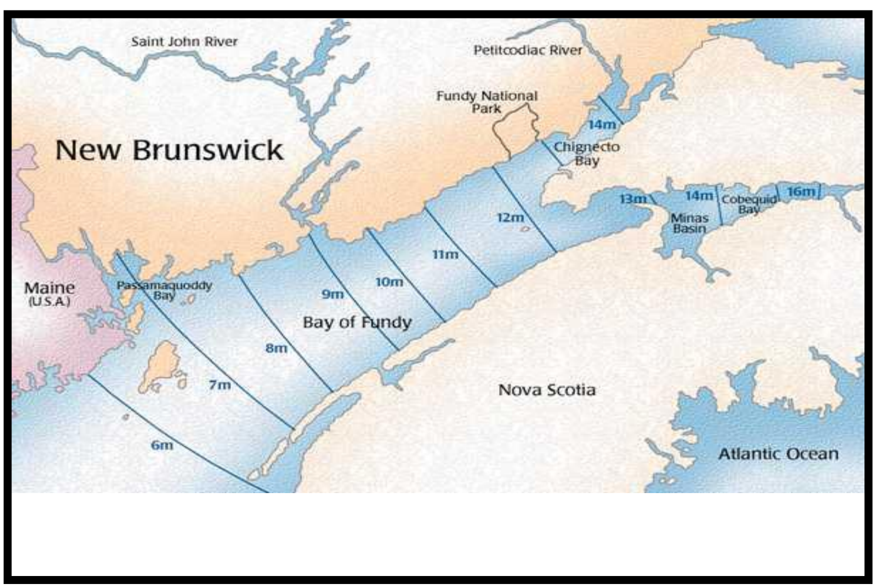
Source: Courtesy of DFO Oceans and Coastal Management Division (4-year composite catch weight (kg) map for 2008-2011 on a combined 10-minute and non-uniform statistical corridor grid).

Figure 33. Scallop Landings 2006-2010



Source: Courtesy of DFO Oceans and Coastal Management Division (5-year composites (2006–2010) of catch weight (kg) per 2-minute grid cell).

Figure 34. Weir Fisheries in Nova Scotia



Source: This study, information courtesy of DFO Oceans and Coastal Management Division.

7.3.2 Potential Environmental Interactions

Environmental interactions with fishery activities vary according to the stage of tidal power development, whether **construction**, **operation**, or **decommissioning** (Isaacman and Daborn 2011). The effects on fisheries can be clustered according to whether they are direct or indirect, and whether the development is a tidal stream or tidal range project. During construction (and to some extent decommissioning) of TISEC sites, direct interactions with fishery activities include safety exclusion zones (which may have to be very large in order to accommodate large and numerous vessels involved in site preparation, drilling, pile-driving, cable-laying, etc.), noise and other disturbances, sediment mobilization, and potential contaminant release. Noise and vibrational effects of construction may have varied implications for different species targeted by fisheries. It is very likely that schooling fish, and any fish possessing a swim bladder or using acoustic signals for communication, will be affected by seismic surveys during site assessment and pile-driving (etc.) during construction. (Research at the Annapolis Tidal Generating Station has shown that underwater acoustic devices have proved effective at driving migratory fish away from the entrance to the turbine, and acoustic monitoring devices may have a similar deterrent effect.) Some of the interaction with fisheries might be avoided if construction is a relatively short phase that could be completed when the area is not actively fished. If target species seek to avoid the site during construction, this displacement may be of short-term significance to local fisheries.

Excavation and site preparation during the **construction** phase will have a variety of effects depending upon both the location and the nature of the substrate. In areas with finer, more mobile sediments such as sand or mud, on the bottom, construction activities may resuspend that material, causing short term effects on fish species, but possibly longer term effects on benthic habitats and organisms. These construction effects are likely to be comparable to many other marine activities, for which monitoring and remediation techniques are well established.

During the **operation** phase, the direct effects would also include safety exclusion zones (although these may not be as extensive as those during construction), the prospect of direct mortality associated with turbine passage, distraction or deterrence of fish from the site, etc. Indirect interactions with fisheries for all stages of development include the consequences of habitat destruction or alteration, and effects on prey and/or predators.

In the case of a tidal lagoon, its construction will probably permanently remove the enclosed area from access by fishery operations. **Construction** is likely to be a prolonged activity in the case of a lagoon, and it is unlikely to be possible to avoid times of fishery activities. Entrapment of commercially important fish during filling of the impoundment may be an important interaction. Most designs for lagoons assume that fish will be able to exit from the impoundment through the turbines, with only a small mortality: proponents commonly claim that their turbine is ‘fish friendly’, although the limited experience with existing barrage-based turbines does not provide much support for that contention. Changes to bottom habitats within the lagoon (and possibly also nearby on the seaward side of the barrier) may have significant effects on fisheries species – both positive and negative. Shallow areas suitable for lagoons often support important stocks of demersal fish such as flounder, which may move into deeper water after spawning, and shellfish stocks such as the soft shell clam. Changes to the sediment deposition regime following impoundment could impact such stocks.

Effects on aquaculture operations of both TISEC and tidal lagoon developments will vary according to location and local characteristics. Shellfish aquaculture is likely to be negatively affected by activities that increase the quantity of sediment in the water column, even if the increased turbidity is a relatively short-lived phenomenon. Changes in current velocity and turbulence are likely also to be detrimental if they affect the quantity and quality of water entering an aquaculture operation.

Development of offshore energy generation sites will require supporting shore-based infrastructure (Howell 2013a; Vanblarcom 2013). This may have both positive and negative implications for fishery activities:

- Potential increase in services available in local harbours:
  - Access roads and ramps;
  - Dockside infrastructure and equipment (e.g. cranes, power supplies);
  - Increased marine surveillance and emergency response systems; and,
  - Repair and maintenance of existing wharf or dock facilities.

- Potential conflicts for:
  - Existing wharf space and services;
  - Financial services; and,
  - Labour.

7.3.3 Environmental Planning and Management Considerations

The potential conflicts between tidal power development and fisheries vary according to the type of development (e.g. TISEC or lagoon), the type of fishery currently under way, and the geographic location. Detailed examination on the management considerations is provided in Jacques Whitford (2008); the following is a brief summary reflecting recent knowledge and assessments.

Minas Passage and Channel

Karsten (2013) has reassessed the energy potential of the Minas Passage and Minas Channel area as ~ 1400 MW. Because of high currents, the only fishery pursued in the Passage and Channel is for lobster, an industry that appears to have increased in scale in recent years. Approximately two dozen license holders operate out of nearby harbours (Dyer *et al.* 2005). Herring fishers fish extensively in Scots Bay and approach the outer part of the Channel, but do not venture close to the FORCE site, and flounder draggers operate both in Scots Bay and portions of the Minas Basin. A short-term fishery for spiny dogfish occurs in the Basin in mid-summer. There are also five extant weir fisheries that capture a variety of commercial and non-commercial fish species that have mostly entered the Basin through the Passage. FORCE and Acadia University have recently instigated a research and monitoring programme in collaboration with local weir fishers in order to monitor fish occurrence and movement patterns (A. Redden – pers. comm. 2013). In addition, drift- and gill-netting occurs at scattered locations, primarily aimed at shad, herring and alewife.

Commercially important finfish that transit through the Passage to be harvested elsewhere (e.g. in the Outer Bay or near/in the home rivers of migratory stocks such as shad and gaspereau) include herring, pollock, spiny dogfish, shad and alewife. Recent research on fish movements in the area indicate that many species utilize the northern half of the Passage where the FORCE test site is located, and where depths range between 40 and 60 m (A. Redden – pers. comm. 2013), but there is little information yet on fish use of the deeper water (<120 m) channel on the south side (Melvin and Cochrane 2012). Tracking of sturgeon, striped bass and eels fitted with individual acoustic tags shows that all of these species use the northern portion of the passage, swimming at depths including those at which test turbines would be operating (A. Redden – pers. comm. 2013).

Tidal stream development activities in the Passage will involve cable-laying, which is expected to be completed by 2015. Installation of test turbines expected to occur in 2015 varied construction and/or excavation activities, depending upon the specific turbine design to be installed. The OpenHydro turbine that was installed in November 2009 (without a cable) was supported on a large gravity base that was deployed on site with the turbine attached, and the entire unit was retrieved 13 months later. A similar approach may be followed by other test turbines. Alternatively, turbines may be installed on a foundation that has been pre-deployed and stabilized by drilling into the substrate, as was the strategy followed in Cobscook Bay (Maine) by ORPC (2013), or on a piling that has been pinned into the substrate to support the turbine and enable access for maintenance. The latter was the approach taken by MCT in Strangford Lough (N. Ireland) and by OpenHydro at EMEC in Scotland. Developers interested in the four berths at the FORCE site have so far indicated deployment strategies ranging from a simple anchoring point to a gravity base.

Gravity bases represent the approach with the least impact on the bottom during construction and deployment, unless some preliminary substrate preparation is required. The environmental effects of gravity bases are primarily associated with scour and habitat alteration during long term operation: deployment is relatively quick, and will have very short time effects on local fisheries. Simple anchoring points may require drilling, although they may also be managed from a gravity base.

Direct mortality on fish resulting from interaction with a turbine is an issue for regional as well as local fisheries, because of the migratory movements of several species through the Minas Passage. Direct mortality can be caused in several ways: a) contact with moving parts such as blades or vanes; b) contact with non-moving parts and/or associated stress of avoidance; c) shear forces; cavitation or sudden pressure drops as a fish passes through the device. Monitoring of fish movements in the vicinity of a TISEC device has so far been done for very few installations, notably: the Verdant Roosevelt Island project in the East River, New York; the ORPC deployment in Cobscook Bay, Maine; and the MCT deployment in Strangford Lough, N. Ireland (indirectly through acoustic monitoring of mammals). None of these monitoring studies showed evidence of mortality for any of the fish passing through the area, but the conditions of each study were limited in ways that it is not possible to discount direct effects on fishery species.

Digby Gut, Grand Passage and Petit Passage

TISEC locations in the Outer Bay will intersect with a greater variety of fishing activities than in the Upper Bay. These include: fixed gear fisheries for lobster and crab; dragging or trawling for scallop, and flounder; seining, hand-lining or trawling for herring, haddock and pollock (etc.); and gill-netting for other pelagic species. Much of the substrate in these areas is bedrock, and while this may limit the necessity for extensive site preparations, the shallower depths and lower current speeds may favour bedrock drilling or support framework pinning approaches as used in Cobscook Bay (ORPC 2013). Noise and vibrations, therefore, remain a potential issue, and the variety of fisheries active over the year mean that there will be very limited 'windows of opportunity' to carry out construction operations without coincident fishery activities. Finfish and shellfish aquaculture operations occur year round in or near these sites, and therefore effects of drilling, site clearance, sediment mobilization, vibrations and noise, will be a concern.

Tidal Lagoon Interactions

Tidal lagoons have so far only been proposed for areas in the Upper Bay of Fundy. Although no comparable examples exist anywhere in the world, there is considerable experience from past barrage-based developments and proposals to recognize the potential interactions of a lagoon with fisheries operations. Within the Minas Basin, lagoon development would have implications for lobster, flounder, gill-net and weir fisheries, all of which, while important to local communities, represent small scale operations relative to larger fisheries in the Outer Bay. Construction is likely to be prolonged, produce a good deal of sediment if a rubble-mound dyke is involved, and entail considerable safety exclusion zones when concrete caissons are put in place. The different construction approach presented by Halcyon (2012) for the Scots Bay area would entail pile-driving and/or drilling activities that would have potential deterrent effects for seining (herring), trawling (flounder) and fixed-gear fisheries (lobster) in the area.

7.3.4 Management Implications

The essence of all these interactions is that management decisions have to be made recognizing the potential implications for a wide range of interested parties: those directly involved in fisheries and aquaculture operations, those who depend upon the same infrastructure resources, and their communities of interest. Because the Bay of Fundy as a whole is a complex, integrated ecosystem, with fish that move between many parts of the system, modifications to any part and effects on fishery activities at any site have potential implications throughout. It is essential that decision-making be made recognizing the interactive nature of the system and community of interests surrounding it. In the absence of a detailed and effective coastal zone management process or plan, a collaborative strategy specifically crafted for tidal power development is essential.

7.4 Fish and Fish Habitat

7.4.1 Definition and Rationale for Selection

The Bay of Fundy provides habitat for a great variety of fish species, some of which are primarily resident within the Bay, some which migrate to the Bay for feeding purposes, and others are transient, moving between the ocean habitat and fresh water spawning grounds. More than 100 species have been recorded, several of which are commercially important within the Bay itself, while others are also commercially fished elsewhere. Anadromous species (i.e. those that spawn in fresh water but go to sea to grow) utilize the estuarine resources of the Bay to varying extents: some move quickly through the Bay on their seaward migration, and others spend time foraging in the Bay before departure. Their susceptibility to changes associated with tidal power development therefore varies a great deal. The varied ecology and diversity of fish species is described in detail in AECOM (2010).

Fish constitute a critical component of the highly productive and diverse Bay of Fundy system. In addition to those that are the target of fisheries in the Bay itself (as described in section 6.13), there are numerous species that are rare or threatened (e.g. sturgeon, salmon, striped bass – cf. section 6.9), are commercially important somewhere else (e.g. sharks), or, although not commercially important anywhere, play a significant role in local food webs. Migratory species in the Bay consist of two groups: those that spawn in tributaries of the Bay and grow at sea (e.g. salmon, shad, alewife, striped bass, sturgeon, smelt), and others that enter the Bay on feeding migrations but spawn elsewhere (e.g. stocks of striped bass, menhaden and shad). Although locally resident fish may soon learn to avoid turbines, all species that move through the high flow passages might encounter TISEC devices, and all species – resident or migratory – might become entrained in the water passing into and out of a tidal lagoon installation.

7.4.2 Potential Environmental Interactions

For all fish, and both tidal stream and tidal range technologies, environmental issues relate to direct effects, such as mortality associated with contact, pressure and shear forces (etc.), and indirect effects caused by the consequences of energy extraction for natural biophysical processes, or the direct effects on other components of local food webs. These are outlined in section 6.1 and Isaacman and Daborn (2011).

Construction activities associated with a TISEC deployment or creation of a lagoon represent the same challenges outlined in section 6.1: habitat destruction or modification, noise, light and vibrations, remobilization of sediments, contaminant release (etc.). These are comparable with many other marine construction activities. There is, however, very little experience associated with operation of TISEC devices, and these have been gathered only through relatively short term measurements or deployments.

The sole turbine deployment at the FORCE test site was that of the OpenHydro device installed by OpenHydro and Nova Scotia Power Inc. in November 2009 and retrieved in December 2010. The turbine ceased operating approximately three weeks after deployment. A short test (1 day) was conducted of a 5 kW New Energy Corporation

Inc. EnCurrent™ turbine in Petit Passage, NS in 2010, by Fundy Tidal. No fish monitoring was conducted during either of these tests, so no conclusions can be derived from them.

From 2006 to 2011, a 65 kW Clean Current™ turbine was installed at Race Rocks, British Columbia. No fish monitoring programme was recorded for this deployment, but divers were periodically sent down to examine the turbine and to monitor changes to the benthic community, and reported no evidence of any mortality of fish or mammals. Fish monitoring using acoustic technologies has been carried out in connection with turbines in the East River, New York (Verdant 2011), and in Cobscook Bay, Maine (ORPC 2012). In neither case was any direct fish mortality observed during operation of the turbines.

The most useful information has been derived from the ORPC project in Maine, where months of acoustic monitoring using a Didson™ acoustic device indicated that fish were common and at times abundant at the site prior to deployment (Zydlewski *et al.* 2010). Following installation of the 150 kW TidGen™ turbine in August 2012, fish abundance has been monitored at times when the tide is flowing using a Simrad™ EK60 split-beam echosounder (ORPC 2013). Analysis of the data is still under way, but to date no evidence has been uncovered to suggest that fish are negatively impacted by the TidGen™ turbine. It is still not clear whether the active acoustic monitoring devices themselves deter fish from moving in the vicinity of the turbine.

7.4.3 Environmental Planning and Management Considerations

The potential environmental effects outlined above will be better informed by on-going research. In order to reach valid conclusions regarding the species and habitat types in areas of future tidal energy interest, additional research, focused on those aspects of fish and fish habitat most likely to be disrupted by MRE projects is required. This work should be tailored to the environments and species of this region, including species at risk. Ecosystem research of this type provides an opportunity for locally based researchers and students to liaise with their colleagues at other Nova Scotia institutions to create collaborative projects that build on work undertaken elsewhere.

7.5 Marine Benthic Habitat and Communities

7.5.1 Definition and Rationale for Selection

The *benthic community* is that group of organisms which is primarily associated with bottom substrates – either the natural sea bed or solid structures such as wharves, pilings and other energy-related infrastructure. The benthic community may be comprised of a wide variety of invertebrate organisms, some bottom-dwelling fish, and some algae. Many invertebrate and plant species are permanently attached to the bottom, but others are usually mobile (e.g. the *epibenthic fauna*). Many species have extended periods – often larval or juvenile stages – during which they are pelagic. The species composition of the benthic community is strongly determined by the nature of the *benthic habitat*: the type of substrate, the strength and periodicity of water movements, salinity, temperature, exposure to the atmosphere (in intertidal areas), the availability of suitable microhabitat provided by other species (e.g. seaweeds), or by the selective action of predators. An extensive description of benthic communities is to be found in Jacques Whitford (2008) and AECOM (2011), but some generalizations may be useful here:

- Rocky substrates predominate in the Outer Bay of Fundy and where tidal passages experience very strong currents that remove finer, more mobile sediments. Rocky substrates harbour by far the greatest diversity of organisms (e.g. more than 2000 species in the Quoddy Region alone). Extreme flows, such as in Minas Passage, may restrict the diversity of the community to a few species of sponges that are able to tolerate very high currents (e.g. > 3 m/sec) (Morrison *et al.* 2012), but at lower speeds, diversity may be very high;

- Sandy substrates are widespread through much of the Outer and Inner Bay, and in parts of the Upper Bay. Species that inhabit these areas include a variety of worms, mollusks and crustaceans that burrow into the sand, or mobile *epibenthic* forms like scallop and lobster that range just over the bottom. An important species that may play a role in stabilizing sandy substrates is the horse mussel, *Modiolus modiolus*, which is associated with ridges of sand referred to as 'horse mussel reefs'; and,

- Finer, muddier substrates are found in intertidal areas of the Upper Bay. The benthic community of these muds is comprised of a few species of worms, crustaceans and mollusks, some of which play significant roles in the food web of the Upper Bay.

The benthic community in the Bay of Fundy is of importance for several reasons:

- Several benthic species, such as flounder, lobster, scallops, crabs, blue mussels, sea urchins and seaweeds (e.g. Irish moss, dulse and rockweed) are the foci of important fishery resources;
- Many benthic species constitute important prey for finfish, marine birds (e.g. eiders), and other mobile predators (e.g. lobster); and,
- The great diversity of species in the Bay of Fundy, associated with its high productivity and the diversity of habitat, is of conservation interest.

7.5.2 Potential Environmental Interactions

Benthic organisms in the area of construction will be directly affected by removal or modification of habitat. In many cases, the effects are likely to be detrimental, but in areas where the substrate is more uniform or more mobile (e.g. sandy or muddy environments), the increase in diversity of habitat associated with TISEC construction could result in an increase in local species diversity. Species responding positively to increased stable substrate will likely include several common biofouling species: seaweeds, and filter-feeders such as mussels and barnacles. Some biofouling organisms are invasive (e.g. tunicates, some algae) and constitute a threat to aquaculture activities. Increasing growth of biofouling species might also materially affect the stability and durability of TISEC devices or infrastructure, requiring continuing maintenance or remediating measures such as anti-fouling coatings. Both cables and TISECs have relatively small footprints on the seabed, and thus are expected to have minimal direct impacts on benthic organisms, similar to other construction projects in the marine environment.

Energy extraction is likely to have a number of different effects on benthic communities. Changes to the current velocity and/or the extent of turbulence, will affect sediment dispersal and settlement, potentially over considerable distances from the development location (i.e. far-field effects). Most species of benthos, particularly filter-feeders, that are adapted to clear, well-flushed sites such as rocky substrates, are susceptible to increases in fine sediments, especially if those sediments are angular or associated with contaminants. Decreasing the current velocity will favour deposition of sediment particles, which may produce a shift in benthic community composition by eliminating more susceptible species, or changing the conditions determining settlement of larvae, etc. Increasing current velocities in some areas, particularly close to the site, could induce scour of the substrate, and eliminate some *infauna* (i.e species that live burrowed within the substrate).

Lagoons, which are more likely to be considered for areas of the Inner and Upper Bay, are expected to exert significant changes to the benthic community in the immediate vicinity. The impoundment barrier itself, whether a rock-fill dyke or concrete caisson, will smother benthic species in the immediate footprint of the development. The addition of new substrate (e.g. the rock or concrete of the impoundment wall) will provide settlement opportunities for hard surface species, or cavities for hole-dwelling organisms like lobsters. Within the lagoon, however, a tendency to accumulate sediment from suspension in the water used to fill the lagoon could materially change the pre-existing substrate, for example causing a shift from sand towards mud. Although many benthic species are well adapted to soft substrates, the continued deposition in each filling cycle might eliminate some. To date, no research has examined the possible effects of a lagoon on benthic communities further afield. However, the modeling by Cornett *et al*. (2011) suggesting that one or more lagoons located in the Upper Bay of Fundy would increase tidal range as far away as Boston by 1-7 cm, could be significant in terms of vertical mixing, sediment deposition, and benthic community structure.

7.5.3 Environmental Planning and Management Considerations

As described in Jacques Whitford (2008) and AECOM (2011) and above, the benthic and epibenthic communities vary markedly throughout the Bay in response to local substrate conditions. Most of the sites suitable for TISEC development are in higher-flow areas such as the passages, where substrates are firm, and, if current speeds are not too high, colonized by a great diversity of benthic species that are important in the food webs of the Bay. Especially in the Outer Bay, potential sites are utilized by marine mammals, fish and birds, which depend in varying ways upon the benthic community. The Upper Bay, near the high potential TISEC site of Minas Passage and where lagoons have been considered, is dominated by sedimentary substrates, extensive areas of which are intertidal and occupied by large numbers of a few species that are critical to several migratory birds and fish.

Energy extraction by a few TISEC turbines in Minas Passage and/or Minas Channel is not expected to have measurable effect on current velocities, turbulence, or sediment deposition except in the vicinity of the development. However, it has been recognised that larger scales of development might eventually trigger benthic habitat changes, especially in Minas Basin, and for that reason, several research projects were initiated and funded by OERA.

Smith *et al.* (2012) used established hydrodynamic and sediment dynamics models, combined with direct measurements of current flows profiles, and sediment concentrations derived both *in situ* and from satellite imagery, to examine the far-field effects of energy extraction in Minas Passage on intertidal and subtidal sediments in Minas Basin. The results show that large scale energy extraction could significantly affect the pattern of deposition of sediments in intertidal areas, especially in the Southern Bight of Minas Basin. In the Passage itself, current flows were reduced in both directions, but apart from causing more water to enter and exit through the deeper channel on the south side of the Passage, and for potential scour effects in the vicinity of the turbines, there is expected to be little obvious effect on benthic substrates.

Van Proosdij and O'Laughlan (2013) have been investigating the variation in sediment deposition patterns in peripheral salt marshes of Minas Basin associated with seasons and the spring-neap cycle as a proxy for the expected decline in current velocities resulting from TISEC development. They found considerable differences between sites representing channels and more exposed intertidal flats in the amount, rates and timing of sediment deposition and resuspension. A primary determinant of the rate of accumulation of sediment was the height of the water at high tide, particularly whether this would give rise to water flooding over the channel sides (as would occur on spring tides), or whether the flood waters were constrained within the channel as is more common on neap tides. In the latter case, the lower ebb flow velocities are unable to resuspend sediments that have been deposited, leading to faster rates of channel infilling. The implication is that a reduction of <5% in the tidal amplitude in Minas Basin resulting from a large TISEC array in Minas Passage could lead to substantial infilling of tidal channels in Minas Basin, and associated changes to adjacent marshes and intertidal flats.

Sheng *et al.* (2012) have examined the far-field effects of tidal extraction over a larger scale that includes the Outer Bay of Fundy, Gulf of Maine and Scotian Shelf. As with Karsten *et al.* (2010; and Karsten 2013), modeling indicates that extracting energy from Minas Passage increases tidal elevations and tidal currents over the Outer Bay of Fundy and Gulf of Maine, but decreases these within Minas Basin. Sheng *et al.* (2012) also found that the effects of tidal energy conversion are much less if the turbines are situated only in the lower half of the water column (within 20 m of the bottom), than if the energy is extracted over the full depth of water. Applying these hydrodynamic model calculations to assess the effect on bottom sediments suggested that extracting energy only from the lower half of the water column would only affect sediments in the Bay of Fundy, not further afield.

7.6 Pelagic Communities

Pelagic fish species are described in general terms in Fisheries and Aquaculture and Fish and Fish Habitat above. In addition to the free-swimming *nekton* – squid, fish, turtles and mammals – that move within the water column, there are several planktonic and small nektonic species of importance to the Bay of Fundy ecosystem. Many of these are very small, and have limited swimming abilities beyond a capacity to select and maintain themselves at specific depths when the turbulence is low. Others are somewhat larger, and a few, such as the comb-jellies and jellyfish, may occur in such large numbers at times that they attract specific predators into the Bay of Fundy. Detailed accounts of the plankton are to be found in Jacques Whitford (2008) and AECOM (2011).

7.6.1 Definition and Rationale for Selection

Planktonic and small nektonic species represent fundamental links in the food webs of coastal waters; consequently, any negative effects on pelagic organisms from energy extraction would be of concern. Many fish are planktivorous at some stage in their life cycle, and some, like herring, shad and alewives, are planktivorous throughout their life. The shallower bays and estuaries of the Bay of Fundy are important nursery areas for some fish, and in larval and juvenile stages they may be particularly susceptible to shearing forces and/or pressure changes or cavitation associated with turbine operation.

Most pelagic organisms – other than fish and mammals – have relatively limited swimming capabilities, and therefore are unlikely to be able to avoid interaction with tidal energy installations if they are present in the water that is drawn through the device. The smallest pelagic forms (microplankton) are unlikely to be directly affected by large scale TISEC devices (e.g. Schlezinger 2013), although the enhanced turbulence associated with these might render small pelagic animals more vulnerable to fish or bird predators. However, other pelagic taxa, such as the larger copepods, euphausiids (i.e. 'krill'), jellyfish, comb-jellies, and squids may play significant roles in food webs and are potentially affected by interaction with a turbine, whether part of a tidal stream or a tidal range installation. Euphausiids and some of the larger copepods are critically important food sources for a number of pelagic fish, some marine birds and for baleen whales. Their availability as prey is often determined by upwelling processes, whereby they may be brought near to the surface where they may be caught by birds and fish. The squids are intermediary between the small plankton and the large nekton, and may deserve special consideration. They are mobile predators that are probably very sensitive to environmental cues that might be related to potential prey, and therefore may be able to detect turbine-generated disturbance in advance, and avoid contact.

7.6.2 Potential Environmental Interactions

Larger soft-bodied forms such as jellyfish and comb-jellies might be particularly susceptible to the shear forces and turbulence associated with TISEC devices. The larger forms tend to be episodic, occurring in large swarms at times in summer; when these swarms appear, they not only have a direct impact upon their smaller zooplankton prey, but also attract a number of specialized predators of their own, including leatherback turtles and ocean sunfish (*Mola mola*).

Any significant changes to upwelling regimes have the potential for indirect effects on fish and birds. If, as hydrodynamic models suggest, large scale energy extraction by tidal stream or tidal range installations results in increases in tidal range – and hence tidal mixing – in the Outer Bay of Fundy, increased availability of deeper-dwelling pelagic species to mammal, fish and bird predators could be a significant outcome.

The effects of tidal range installations, such as lagoons, are equally varied. Research at the Annapolis Tidal Generating Station has shown not only that passage through a tidal range turbine has significant mortality implications for larval and juvenile fish, but that turbulence in the outflow of the turbines can bring poorly-swimming organisms to the surface where they are more susceptible to predation by birds and fish.

The majority of pelagic species are relatively small in size and unlikely to be affected by pressure changes during movement through MRE devices. However, there are larger species that also exhibit limited mobility and are therefore unable to avoid TISEC devices. These species are susceptible to changes in pressure and to shear force that occur when they are carried through a turbine. They may also be affected by increased noise and vibrations associated with the installation, operation and decommissioning of turbine generators. The effects may not be limited to macrofauna. Of particular concern are the eggs and larvae of species that play key roles in marine ecosystems (e.g. lobster).

7.6.3 Environmental Planning and Management Considerations

Single turbines and small array deployments are unlikely to cause significant damage to pelagic communities, but preparation for larger installations must include consideration of the critical ecological role played by these organisms. Changes to water circulation resulting from energy extraction may have important effects on the dispersion and survival of some planktonic and nektonic species, as well as the dispersive phases of benthic species.

7.7 Marine Mammals

Twenty-two species of marine mammals are known to occur in the Bay of Fundy. Tidal currents, upwelling, and oceanic fronts generate well-mixed, nutrient rich waters and a consequent abundance of plankton, attracting baleen whales and numerous species fed upon by toothed cetaceans, particularly to the Outer Bay where these highly productive areas are most significant. Both resident and migratory marine mammal species take advantage of the Bay: seven of these species occur commonly, five are occasional visitors and others occur rarely. Further details regarding the species found in the Bay, their ecology, movements and importance, are to be found in Jacques Whitford (2008) and AECOM (2011).

7.7.1 Definition and Rationale for Selection

Marine mammals are a highly valued component of the Bay of Fundy's ecosystems. Aside from their critical role in the marine food web, marine mammals are highly valued due to their charisma, which drives whale-watching tourism ventures and wins the hearts of locals and tourists alike. There are several species of special concern including, whales (notably the North Atlantic right whale), porpoises, dolphins and seals. At either demonstration or commercial scales, TISEC development is anticipated to have direct and indirect implications for marine mammals. Because tidal lagoons are only proposed for shallow locations in the Upper Bay and whales are primarily found in the Outer and Inner portions of the Bay, porpoises and seals are most susceptible to the potential effects of tidal lagoon development; however, larger whales occasionally roam to all parts of the Bay of Fundy, including Minas Basin.

7.7.2 Potential Environmental Interactions

For both tidal stream and tidal range technologies, environmental issues impacting marine mammals relate to direct effects, such as mortality associated with contact, and indirect effects, such as mortality effects on prey, changes in food concentrations as a result of changes in upwelling, and disturbance effects of construction and operation (etc.). The potential environmental implications of tidal energy development on marine mammals are discussed in detail in the previous Strategic Environmental Assessment Background document (Jacques Whitford 2008). Risk assessment of tidal energy development focused on marine mammals has identified potential effects, providing valuable insight required to plan mitigation measures, and to inform decisions regarding monitoring priorities.

Potential effects of TISEC development on marine mammals include:

- Deterrent effects of excavation and installation activities associated with noise, vibrations and possibly artificial lighting at night;

- Deterrent effects of operation associated with noise or vibrations, especially those species that use sonar for pursuing prey;
- Disruption of communication between mammals as a result of increased underwater noise;
- Direct collision or contact with TISEC devices; and,
- Indirect effects through changes in prey distribution and abundance, both of fish that may be deterred from the vicinity of the device and other prey that are concentrated as a result of upwelling.

The susceptibility to these potential effects varies among the mammals that utilize the Bay of Fundy. All may react negatively to the noise of pile-driving or drilling operations. Similarly, all mammals use sounds to communicate within their group: many of the whales use low-frequency sounds for long- distance communication, and some species use sonar to track prey. Increasing the noise level in the restricted areas of the passages on a continuing basis could have significant effects either by direct deterrence, by interfering with the animals' ability to navigate or communicate using their own sounds, or to track food. Because of the novelty of TISEC devices, there is little information available to assess these implications; however, research at Danish offshore wind farms has shown that animals using sonar for tracking prey (*e.g.* porpoises) avoided the wind farms almost entirely during construction, whereas seals did not (Dong Energy *et al*. 2006).

There is little evidence that marine mammals come into contact with large stationary objects in the marine environment. Most of their encounters are with fishing gear that may be too small to be detected underwater (ropes, traps, weirs, etc), or with moving objects such as vessels. Entanglement in ropes and cables that may not be readily detectable by marine mammals is a risk that still has to be evaluated, and may be an issue mitigating against the use of tethers for TISEC attachment. However, it is not clear whether underwater noise or vibrations from an operating TISEC device will confuse signals and diminish the mammals' capacity to discriminate hard surfaces, which might result in them encountering the device. Although not an exact analogy, it is well known that seals remain in the vicinity of the Annapolis Tidal Generating Station, especially during the shad and gaspereau runs, and on two occasions humpback whales have moved into the Annapolis headpond, probably in pursuit of fish. There are no records that any of these animals have interacted with the turbine itself. In the absence of empirical evidence, there have been attempts to model the likelihood of mammals or fish encountering a TISEC device (EquiMar 2011h). These models are based upon predator-prey encounter-rate studies and experiments on avoidance behaviour of animals to a 'looming threat'. The weakness of these numerical models lies in the limited knowledge of mammal perception of devices, especially under the high flow conditions of interest for TISEC deployment.

Indirect effects, such as changes in food concentrations as a result of changes in vertical mixing of the water column, are possible implications, especially for those species (*e.g.* minke, finback and right whale) that feed on planktonic animals. Whether this is a significant implication depends upon location of the TISEC development relative to feeding areas, the scale of development, and therefore the extent of changes to mixing zones. Answers to these questions could come from future modeling exercises, since the development of numerical hydrodynamic models of energy extraction in the Bay of Fundy has reached the stage that the far-field effects of large scale developments are well-described (Sheng *et al.* 2012; Karsten *et al*. 2011; Karsten 2013).

Recent monitoring of cetaceans at the FORCE site has confirmed that the most common marine mammal species is the harbour porpoise (Tollit *et al.* 2011; Wood *et al.* 2013; Porskamp *et al.* 2013). As yet there is no direct information regarding their behaviour in the vicinity of a TISEC device, although harbour porpoises have been recorded in Strangford Lough (Northern Ireland) where the MCT SeaGen™ turbine has been deployed for several years: there have been no instances recorded of interaction with the operating turbine.

Tidal lagoons represent a different suite of potential interactions with marine mammals. Experience with marine mammals at the Annapolis Tidal Generating Station indicates that marine mammals (seals, porpoises and occasionally whales) are present downstream of the tidal generating station, and that they occasionally pass upstream through the fishway, but have never been recorded as transiting through the turbine itself. On two occasions large whales (probably humpback or fin whales) were observed in the Annapolis headpond, but both apparently left the area unharmed – presumably exiting through the fishway again. At the Scots Bay site proposed as a lagoon by Halcyon (2012), seals, porpoises, and whales are common, and if, like at Annapolis, are able to move into the lagoon, there will be the potential for entrainment. At present, the risk is difficult to assess.

7.7.3 Environmental Planning and Management Considerations

Marine mammals are found throughout the Bay, and thus, any development site holds potential to impact marine mammal presence and activity. Because of the limited knowledge of marine mammal interactions with turbines, and the few technologies available for monitoring in high flow tidal areas, there has been a reliance on shore- or vessel-based observers to monitor animal presence in tidal sites. This technique has been used at Strangford Lough[11] (Northern Ireland), Puget Sound (USA), FORCE and the Fundy Tidal Inc. sites on Digby Neck (Nova Scotia). In spite of the limitations (inability to detect mammals except at the surface, and limited ability to observe behavioural responses), observer-based monitoring is a valuable initiative: it is relatively cost-effective, and has the virtue of increasing constructive public involvement with development projects.

FORCE has supported studies of acoustic monitoring technologies and of mammal movements in Minas Passage, and will be expected to continue those studies when turbines are deployed. Development of sites in the Outer Bay of Fundy may have a greater influence on marine mammals, as these areas have the highest diversity and abundance of marine mammals in the Bay (Jacques Whitford 2008). The tidal energy development sites on Digby Neck have a high potential for use by whales as well as cetaceans. An Environmental Monitoring Programme (EMP) will be developed and implemented to address potential impacts of tidal energy development on marine mammals. The EMP will likely include the use of passive and active acoustic monitoring systems to detect marine mammals.

The principal uncertainty regarding risk to mammals is the lack of data on marine mammal behavioral responses to tidal turbines, particularly their activity level or usage of areas with strong tidal flows. There is still limited data available on the occurrence of marine mammals in the Upper Bay of Fundy, although this gap is being filled by studies involving PAM technologies (CPODs and icListen hydrophones). However, marine mammal behavioural responses to TISEC devices in the Bay of Fundy cannot be determined until technologies are deployed. It is thought to be unlikely that mammals will venture close to devices, but prior to construction and operation of TISEC developments, predictions from risk assessments cannot be verified. Effects are likely to depend on the species of mammal, and vary between sites and technologies; therefore, project specific environmental management is required. Despite findings being project specific, marine mammal research and monitoring programs at existing marine energy development sites can provide valuable insight. Experience can help determine the potential effects, provide information about particular species' behavior, and afford examples of monitoring methodologies and mitigation measures. For example, Ocean Renewable Power Company (ORPC) is implementing "Fisheries and Marine Life Interaction Monitoring Plans" and an "Acoustic Monitoring Study Plan" for their Cobscook Bay Tidal Energy Project; the framework of these plans, as well as developments in the UK may be used to inform project planning in Nova Scotia.

7.8 Marine Birds

The Outer Bay of Fundy is well known for the abundance and diversity of birds that reside there or visit during seasonal migrations, reflecting both the high productivity of the Outer Bay as well as the diversity of habitat available, which provides opportunities for many species with different ecological roles and requirements (cf. AECOM 2010).

[11] Shore-based observers at Strangford Lough were supplemented by submarine acoustic sensors to detect seals and other marine mammals.

While the Upper Bay exhibits less diversity, some of the migratory stocks that visit appear to be dependent upon the specific opportunities for feeding provided by the highly productive intertidal zone.

7.8.1 Definition and Rationale for Selection

Susceptibility of the marine bird fauna to tidal power-related development varies according to the ecology of each species and the portion(s) of the Bay of Fundy that they utilize. Many of the smaller marine birds, such as phalaropes, terns, shearwaters and petrels, feed extensively in convergence zones on plankton or small fish that are brought near to the surface by upwelling processes. Larger fish predators such as cormorants, loons, some gulls and mergansers, are also associated with upwelling areas. Others, like the diving ducks, congregate and feed where access to benthic animals like mussels is available, and thus are found often in large numbers in shallow waters, particularly those of the passages. In the Upper Bay, the principal groups are migratory shorebirds such as sandpipers and plovers, which arrive in vast numbers during summer to feed on invertebrates exposed in the intertidal zone.

The marine bird fauna is an important component of the ecosystem in all parts of the Bay of Fundy, and so constitutes a group of concern for tidal power developments. In addition, the extensive migratory movements of marine birds links the Bay of Fundy with far distant ecosystems, including the Canadian arctic, and the whole of the North and South Atlantic (AECOM 2010).

7.8.2 Potential Environmental Interactions

The potential risks posed to marine birds vary strongly in terms of their ecology, the characteristics of the tidal power development, and the site location. Noise and vibrations associated with construction activities will act as a deterrent to all species of birds no matter where the development takes place. Where construction and site preparation are limited in time, the effect on birds may be temporary, and may be mitigated by avoiding critical periods for resident and migratory species using the area. Longer construction phases (e.g. for a lagoon or larger TISEC array) obviously increase the risk of disturbance, and since most parts of the Bay have marine birds throughout the year, minimizing the interaction will be more difficult.

During operation of a TISEC installation, the potential for interaction with marine birds will vary according to location, especially the depth and the ecological features of the site. Diving birds, such as eiders, frequent the passages between islands in the Outer Bay, where they feed on mussels at depths of several meters; similarly, cormorants pursue their fish prey to such depths. Both species probably will avoid the highest flow regions, and may be deterred by noise and vibrations from a turbine. Conversely, cormorants and other fish and plankton feeders might find the turbulent wake of a turbine provides an attractive place to forage when the device is operating.

In the Upper Bay, few diving birds frequent the high flow region in the Minas Passage except during the relatively slack tide periods, and so cormorants and loons are relatively uncommon except near shore. As indicated above, however, there may be good foraging opportunities downstream of actively operating turbines.

Tidal lagoons pose a somewhat different suite of interactions. The impoundment behind a lagoon could become an attractive place for some species to feed – both diving birds (terns, cormorants, eiders) and surface feeders (e.g. dabbling ducks, gulls). The Annapolis Tidal Generating Station has operated for over 25 years without any apparent negative effect on marine birds. In fact, observations suggest that gulls and other surface-feeding birds appear to be attracted to the tailrace during operation of the turbine, presumably because there is an enhanced opportunity to capture small prey disoriented or brought to the surface by the turbulence.

In general, there seems to be relatively low risk of direct interactions of tidal stream developments with marine birds, but the same may not be true of indirect effects. Energy extraction from the water has a variety of ecological implications over considerable distances from a power station, regardless of whether that is a tidal stream or a tidal range development. Changes to upwelling zones, especially in the Outer Bay, could significantly affect the foraging success of the many species that feed there, with consequent effects for the whole food web. In the embayments, including Minas Basin, changes in sediment distribution and stability resulting from energy extraction could be of great significance to migratory species such as wading birds, which depend upon invertebrates such as worms and crustaceans, whose abundance and distribution are critically linked to sediment characteristics.

7.8.3 Environmental Planning and Management Considerations

Although the risk of tidal power development to marine birds does not appear to be as great as to other fauna, some of the species utilizing the Bay are migratory, moving between other ecosystems, often far distant ones. These are the basis for a number of international conventions (e.g. Ramsar Convention on Wetlands, Western Hemisphere Shorebird Reserve) that place a higher level of scrutiny upon critically important habitats like the Bay of Fundy. The birds are also much more visible to people, and constitute an important natural and recreational focus. Numerous naturalist groups exist around the Bay of Fundy, and while these groups represent a potential resource in terms of accumulated knowledge and monitoring capacity, they also constitute an acute overseer role as tidal power developments advance.

7.9 Species at Risk

It is no surprise that in a highly productive, highly diverse ecosystem such as the Bay of Fundy, and one where marine resources have been harvested for centuries, there are many species that are rare, or whose stocks have become depressed. In addition, many species travel to the Bay of Fundy from very different ecosystems, and are considered of high priority through a variety of international obligations (e.g. Ramsar, Western Hemisphere Shorebird Reserve system).

7.9.1 Definition and Rationale for Selection

Species that have been officially recognized by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) as being at risk (SAR), are classified as being either **Endangered**, **Threatened,** or of **Special Concern**, and are protected under the federal *Species at Risk Act* (SARA). Because of this status, species at risk have a high conservation value. Five SAR species occurring in the Nova Scotia portion of the Bay of Fundy are registered as Endangered under Schedule 1 of the SARA Registry: North Atlantic right whale; Northern bottlenose whale; roseate tern; porbeagle shark; and the Inner Bay of Fundy stock of Atlantic salmon. Four species are recognized as Threatened: striped bass; cusk; spotted wolffish; and Peregrine falcon. Those listed as of Special Concern include: Harbour porpoise; fin whale; North Atlantic beaked whale; Atlantic cod; Atlantic wolffish; winter skate; and shortnose sturgeon. Dadswell (2010) indicates that Atlantic sturgeon have also been registered as of Special Concern.

7.9.2 Potential Environmental Interactions

The implications for species at risk may be similar to their taxonomic and/or ecological group (cf. Jacques Whitford 2008). Fish and mammals, and possibly diving birds, for example, may encounter a TISEC device if they commonly swim at depths at which the turbines are operating, and suffer as a result of contact, entrainment, pressure changes (etc.) as outlined in previous sections. However, recent studies by Stokesbury *et al*. (2012) and Redden *et al.* (2013) in Minas Passage have indicated that preconceived notions of animal behaviour may be faulty: for example, Atlantic sturgeon have been detected moving at all depths in the water column, not just near the bottom as has commonly been supposed, and swimming depth among striped bass seems to be age-related, meaning that some age/size groups would be more vulnerable than others.

At present, very little experience enables us to assess the risk to fish and mammals of encountering submerged tidal stream generators because we have little information on their ability to sense and avoid the device(s). Turbines will emit noise and vibration that may deter species at risk from staying in the area, but experience at Strangford Lough

(Northern Ireland) does not suggest that seals moved away from a preferred habitat except during the periods of construction; when that was over, they returned to the waterway, but carefully avoided the immediate vicinity of the turbine when it was operating.

In the Outer Bay of Fundy, right whales are common, mostly on the northern side of the Bay, and are rarely seen near the inter-island passages of Digby Neck; fin whales are more common on the Nova Scotia side, and may frequent the passages themselves, especially as juveniles. It would appear that the risk to these species from TISEC development in the passages is not high.

Lagoons of any design offer a chance for fish and mammals becoming trapped within the enclosure, with the prospect of being forced to exit through the turbines. This is similar to barrage-based tidal power developments, such as at Annapolis Royal and La Rance (France). From the Annapolis Tidal Generating Station there is substantial evidence that fish may suffer direct mortality as a result of entrainment, and are quite likely to become trapped in the headpond during upstream migrations or during sluicing activities. Mammals, on the other hand, may be able to avoid some negative consequences: seals and two whales have been recorded above the barrage at Annapolis Royal, presumably having entered through the fishway, but no evidence has been obtained suggesting that they exited the headpond through the turbines, nor have any carcasses been found within. The assumption is that they had the capacity to find their way out.

Indirect effects of entrainment of fish have been seen at Annapolis, where birds have learned to gather near the tailrace as the turbine begins to operate, where they feed on larval and juvenile fish that may be disoriented or forced near the surface as a result of downstream turbulence.

7.9.3 Environmental Planning and Management Considerations

The lack of direct experience with extended TISEC deployments stresses the importance of continued evaluation of the risks to SAR species. At Strangford Lough, Race Rocks, Cobscook Bay and the FORCE site, observers on land and on ships-of-opportunity have been employed to monitor marine mammals and birds. At Strangford Lough, Cobscook Bay and FORCE also, active and/or passive acoustic devices have been employed to monitor important mammal species or fish, with a focus upon SAR species. Such technologies are rapidly developing, and offer the opportunity for evaluating risk to these marine mammals in the future. It may also be that active acoustic devices, such as those that are used to monitor fish movements, may in themselves be important deterrents for mammals, driving them away from TISEC turbines.

In addition to the management considerations discussed above, an important opportunity exists to recruit Mi’kmaq people, fishers and other local resident to participate both in monitoring activities and research. Expansion of participation in this way has value not only in enhancing understanding of the presence of SAR species and the role that these TISEC-suitable sites play in their life cycles, but also a greater knowledge of and involvement in integrated coastal zone management among the public at large.

7.10 Marine Transportation

7.10.1 Definition and Rationale for Selection

Marine transportation is an issue of interest because many of the sites suitable for TISEC development, especially in the Outer Bay of Fundy, are adjacent to areas of existing vessel traffic associated with ferry services, fishing, and recreation. Although the present concepts for lagoon development are not proposed for areas with commercial shipping, those areas are used by fishing and recreational vessels. Commercial marine transportation, including fishing requires unimpeded access to and from port facilities, regular and emergency anchorages, and adequate passage through confined channels.

Movements of vessels in coastal waters are regulated under the *Navigable Waters Protection Act* (1985). Tidal stream energy development represents a potential direct conflict with existing marine transportation activities in two ways: during site preparation, deployment and decommissioning, relatively large safety exclusion areas will be required to avoid interference; and during operation, some activities, such as fishing may have to be ended because of safety issues or potential damage to TISEC devices. Any lagoon development in an area used by other vessels will, in addition to the extended safety exclusion area during construction, either require permanent exclusion of vessels from the area behind the barrier, or will have to incorporate expensive vessel passage facilities.

7.10.2 Potential Environmental Interactions

The potential environmental issues related to transportation issues are described in Jacques Whitford (2008). They can be summarized as follows:

- Tidal stream installations in the passages along Digby Neck would be expected to occur in relatively shallow waters (typically <30 m; Trowse *et al*. 2013a) in areas that are used by fishing and recreational vessels for transit between the Bay of Fundy and harbours or Saint Marys Bay or Annapolis Basin. Completely submerged installations, as in Cobscook Bay, are unlikely to impede small vessel traffic, but surface-penetrating or floating structures could represent a permanent restriction for other vessel activity;

- For safety, site preparation and construction phases will require exclusion of all other vessels (fishing, recreational and commercial) from a zone surrounding the site that is large enough to ensure minimum risk to vessels and operators. The area of safety exclusion may have to be increased at times in order to accommodate large vessels (with or without towed barges) involved in drilling or transport of turbines and foundations, etc. A large safety exclusion area could be a significant challenge in Digby Gut if it affects the movements, mobility or safety of the Digby—Saint John ferry;

- During TISEC operation, fishing activities may have to be curtailed in an area sufficient to ensure safety of fishers and to minimize the potential for fishing gear (etc.) to foul the turbine(s);

- At all times, but especially during construction, there may be increased traffic involving supply and maintenance vessels;

- Increased vessel activity will have implications for nearby wharf and service facilities;

- Where a lagoon is to be constructed, the headpond area behind the lagoon wall is expected to be removed from access by other commercial and fishing vessels, although this may not apply to recreational or aquaculture-related activities; and,

- Reduction of tidal range in the Minas Basin associated with energy extraction may have implications for access to harbours in the Basin, such as Parrsboro and Delhaven.

7.10.3 Environmental Planning and Management Considerations

The creation of safety exclusion zones will have somewhat different implications depending upon the site. The only fishing activities in the Minas Passage are associated with lobster boats, although herring seiners do appear to penetrate into the Minas Channel at times (M. Dadswell, pers. comm. 2013). For many years, the only large vessels transiting through the Passage were bulk gypsum carriers visiting Hantsport, research vessels, and Transport Canada vessels maintaining channel marker buoys. The Hantsport operation of Fundy Gypsum Company closed operations in November 2011, and since that time no bulk carriers have entered the Basin.

During site preparation, construction and deployment, safety exclusion zones will have to be identified and monitored. In Digby Gut, Petit Passage and Grand Passage, sites will have to be located away from the existing ferry traffic, and measures taken to ensure that operations of the ferries are not compromised. Digby Gut is extensively used by the fishing industry to move between harbour facilities and fishing grounds. Present mooring facilities may be inadequate in all of these passages for service and deployment vessels, and the presence of aquaculture operations in Digby Gut and the nearby Annapolis Basin will be a potentially constraining element.

The lagoon locations so far proposed are largely away from marine transportation foci. The Scots Bay proposal would enclose a small harbour at Scots Bay used by local fishers, and alternate facilities would have to be made available. The Minas Basin lagoons tend to be located away from the shoreline, and the major implication for local harbour users in Minas Basin would be competition for facilities and space.

Project boundary markings and navigational alerts are established through discussions and submissions by the project proponent to Transport Canada. Neither Transport Canada nor Fisheries and Oceans Canada can establish permanent exclusion zones for tidal energy projects. Negotiations regarding temporary and permanent access limitations are held between project proponents and other area users with interests in the project site. These people may include finfish and shellfish harvesters, marine transporters, Mi'kmaq peoples, tourism operators, recreational boaters and in some cases, coastal residents. Management of these issues will require effective and extensive consultation among the respective stakeholders.

7.11 Tourism and Recreation

The Bay of Fundy constitutes an important tourist attraction, based upon its scenic beauty and diversity, and its geological and anthropological history. The Nova Scotia portion includes numerous historic sites, a UNESCO Biosphere Reserve, two UNESCO World Heritage sites, two national historic sites, and a number of Provincial Parks and Reserves (Figure 35). While the high tidal range in the Upper Bay and occasionally strong wave conditions in the Outer Bay tend to limit some forms of recreational boating, some marine-based activities such as sea-kayaking, whale- and bird-watching and bore-riding are important local activities that have been increasing in recent years.

7.11.1 Definition and Rationale for Selection

The high importance of tourism and recreation to the communities around the Bay means that all marine energy issues have to be carefully evaluated for their impact upon these economic resources. Construction and deployment of energy extracting devices will entail a significant amount of land- and water-based activities that may conflict with existing tourism and recreation operations, especially pile-driving or rock-dumping, for example. At the same time, interest in marine renewable energy is increasing, and having a world-class installation in Nova Scotia waters is likely to attract additional visitors to the area in the same way that the Annapolis Tidal Generating Station did in the 1980s, and the operating MCT turbine does in Strangford Lough (Northern Ireland) today. Because of the potential for both conflict and synergy, the interaction between tidal energy and tourism and recreation is significant. It requires careful consideration and effective cooperation.

7.11.2 Potential Environmental Interactions

The major aspects of interaction are described in some detail in Jacques Whitford (2008), and are briefly summarized here:

- Construction and site preparation for both TISEC and lagoon developments will have similar effects on marine-based tourism activities as on fishing and transportation activities (etc.) as described above. Any temporary or permanent access limitations or safety exclusion zones instituted for marine transportation and safety will naturally apply to recreational boating and sightseeing excursions. Similarly, access limitations during construction / maintenance / decommissioning will also apply to tourism and recreational vessels. As noted above, some restrictions would be temporary and similar to those that occur during other marine construction projects, while any permanent restrictions would be negotiated between the project proponent and the affected parties;

- Many tourists are attracted by the scenic character of the shoreline and marine seascape, and may consider the quality of that experience compromised by visible construction activities, although, once established, many TISEC deployments may well be virtually invisible during operation;

- Disturbance effects on marine mammals and birds are expected during construction and development phases as a result of noise, lights, pile-driving, dumping, etc. This will directly impact those tourism and recreational activities focused on marine birds and mammals; and,

- Indirect effects include conflicts over land-based resources such as harbour facilities and access, accommodations, ferry operations and capacity, etc.

In contrast to these largely negative potential interactions, we note the FORCE Visitor Centre near Parrsboro, NS attracted 3,700 visitors in 2012 (M. Lumley, pers. comm. 2013), indicating the general interest and tourism potential of this industry.

7.11.3 Environmental Planning and Management Considerations

The fact that both positive and negative effects on tourism and recreation could result from marine energy development means that effective consultation among stakeholders is a necessity. Some disruptive activities, such as those during construction (etc.) might be carried out at times (e.g. winter months) when their impact on tourism and recreation would be much less. This might have a beneficial effect in itself: in Strangford Lough, for example, many hotels and restaurants stayed open all year to accommodate site personnel instead of closing after the summer tourist season was over.

Visual impact is a potential concern for all MRE developments. In the case of offshore wind farms in Denmark, however, negative reactions declined significantly after a farm was established because the actual visual impact proved to be less than originally feared (Dong Energy 2006). Most TISEC activities are expected to have limited structures visible at the surface, and those which do bear some similarity to existing marine structures (e.g. the Strangford Lough piling is not unlike a large channel marker, an object that is a familiar feature of navigable coastal waters). Effective communication between the developers, the local public, and tourism stakeholders is essential.

7.12 Archaeological and Heritage Resources

The Bay of Fundy has been the site of human activity for at least 10,000 years, following retreat of the glaciers of the last ice age. The earliest human occupants were probably nomadic, following large herds of migratory mammals such as caribou (Jacques Whitford 2008). During the cool period known as the Younger Dryas (around 11,000 years before present -ybp) these early occupants may have been driven away by glacial advance, but a settlement was in place at Debert by about 10,600 ybp. Following retreat of the ice, sea level began to rise from the low level of 60-70 m below the present sea level, eventually covering over any evidence of coastal inhabitants. By 5,000 ybp, sea levels were approximately 15 m below present levels, but rebound of the land once the weight of glacial ice had been removed (Roland 1982) meant that the land level itself was relatively high. As the land later subsided, forests of hemlock and oak were submerged. These relative sea level changes, complicated as they are by land movements, the increase in tidal range, and by tidal scour (Shaw *et al.* 2012), mean that much evidence of human activity between 10,600 ybp to European contact in the 15th/16th centuries has been lost. What remains is therefore of enhanced significance. An extensive review of archaeological resources is to be found in AECOM (2010). There does not appear to have been any new archaeological or heritage resources identified in the study area during the last 5 years, but compiling of information regarding Acadian conversion of salt marshes in the Grand Pré area of Nova Scotia, based on the work of Bleakney (2004), led to that shoreline being recognized as a UNESCO World Heritage Site in 2011.

7.12.1 Definition and Rationale for Selection

Archaeological and heritage resources are defined as any physical remnants found on top of and/or below the surface of the ground that inform us of past human use of and interaction with the physical and biological environment. For the purposes of the SEA, this includes all marine artifacts and resources that may be found under water or on the near shore that might be affected by changes in water levels, erosion, deposition (etc.) arising from the development of tidal power. Unfortunately, knowledge of Aboriginal existence and activities in the Bay of Fundy is limited to a few areas that have been studied by dedicated archaeologists (Jacques Whitford 2008; AECOM 2011, AECOM 2009): mainly Minas Basin, Scots Bay and Digby Gut. There are many stretches of the Bay of Fundy shoreline that have never been examined. Recent multibeam surveys of the Bay (Parrott *et al.* 2009) have provided a greatly enhanced knowledge of the substrate conditions in the Bay of Fundy, although many shallow areas adjacent to shore, where heritage resources might exist, have not yet been surveyed. Efforts are currently under way to link multibeam bathymetry with LiDAR surveys to fill in the coverage of near shore areas (e.g Parrott *et al*. 2008).

7.12.2 Potential Environmental Interactions

Installation and maintenance of land-based structures (e.g. cables and other electrical works, harbour or wharf expansion, infilling, etc.) associated with tidal stream development could potentially destroy existing but unknown heritage sites or artifacts, including those of Aboriginal people. Laying of cables under water, site clearance, device deployment, monitoring infrastructure (etc.) could similarly affect submerged resources, including shipwrecks, which are especially numerous in the Nova Scotia portion of the Bay of Fundy.

The effects of extracting energy from the tides, as described by Karsten (2013), Karsten *et al*. (2008), Sheng *et al.* (2012) and Smith *et al.* (2012) include changing the strength and pattern of currents, and the pattern(s) of sediment distribution over considerable distances, which might expose or bury existing heritage resources. Similarly, the secondary effect on wave climate (Martec 2011) in the Minas Basin would be a factor affecting shoreline erosion, a process that not only exposes geological evidence of past life (e.g. at Joggins and Parrsboro), but also of human habitation. In the vicinity of Delhaven, Minas Basin, continuing erosion of the sandstone cliffs has been exposing centuries-old cemeteries and habitations; decreasing wave attack on the shore could reduce that process. It is likely that present-day submerged landscapes in high current areas such as Minas Passage have less archeological potential, due to the erosive effects of the strong currents.

Development of a tidal lagoon project in Minas Basin would have similarly important implications for heritage resources. Apart from the large footprint of a rubble-mound dyke, which would cover over a large area of ground, it is likely that areas of scour may be induced around the structure (mitigated by rip-rap), but within the impoundment, sediment settlement might be effective at preserving historic artifacts. The Halcyon proposal for Scots Bay, would have a relatively low footprint on the bottom, but is located near an area of particular archaeological significance. There are a number of Aboriginal sites in this area, apparently associated with North Mountain chalcedony, a rock used for making chipped stone tools, as well as the local fishery resources. Protection of the shoreline behind the barrier from wave and tidal surges would potentially serve to protect such resources.

7.12.3 Environmental Planning and Management Considerations

In the absence of existing information on near-shore locations of the Bay of Fundy, it will be necessary to apply modern bathymetric and LiDAR survey techniques to investigate sites that are considered for tidal power development. The areas of concern will include not only the immediate vicinity of the development, but potentially areas further afield where changes in erosion and sedimentation processes could either cover or uncover heritage resources. Any identified resources would then be examined using modern video or sonar techniques (including diving where feasible), to ascertain the significance of the artifact and assess the prospects for protection or salvage.

7.13 Economic Development

A blueprint for the development of marine renewable energy was prepared in 2011 by a consortium of primarily business interests (OREG 2011). Entitled *Charting the Course: Canada's Marine Renewable Energy Technology Roadmap*, the document outlined a vision for MRE development that included:

- Development of more than 75 MW of renewable energy in the form of tidal, wave and river-current energy solutions by 2016, and 2,000 MW by 2030;
- Up to $2B of annual economic value by 2030; and,
- More than 50% of global MRE projects utilizing Canadian products or expertise.

The probability of achieving the first goal (75 MW by 2016) is extremely small, primarily because of delays associated with technical and environmental challenges facing the industry and developers, and the failure of private sector financial sources to contribute until very recently. Within the last year, there have been more encouraging signs that major financial and industrial partners are assessing the risks as more acceptable, with some major international companies acquiring ownership of MRE technologies (e.g. Siemens, Alstom, etc.). The 2030 targets (2,000 MW and $2 billion value) may still be out of reach, but as technical and environmental risks are better understood there is room for increasing optimism.

Nova Scotia's present dependence upon imported coal for electricity generation is being addressed by an ambitious plan to increase the proportion of electricity generated from renewable energy, as outlined in the *Nova Scotia Renewable Energy Plan* described in section 2.3. The goal of 40% renewable energy by 2020 has been confirmed in the *Nova Scotia Electricity Act* (Obermann 2013a). During the 2007-2008 SEA for tidal power in the Bay of Fundy, a series of public consultation sessions was held in communities in Nova Scotia. One of the strongest recommendations made by many participants in those meetings was that, while they were cautiously optimistic about the prospects for tidal power development (especially tidal stream technologies), it was imperative that it should benefit economic development in the province, and particularly the communities adjacent to the resource (OEER 2008; Government of Nova Scotia 2012).

7.13.1 Definition and Rationale for Selection

The benefits of replacing fossil fuels with renewable sources of energy include:

- Diminishing Nova Scotia's contribution to greenhouse gas emissions;
- Stabilizing power rates by removing the fluctuations of commodity prices;
- Providing energy security; and,
- Providing economic opportunity for business and communities in Nova Scotia.

These goals are important, and are being met in part by increasing the contribution of wind energy. A major advantage of tidal energy, however, is its predictability, and the massive tides and tidal currents of the Bay of Fundy represent a very large resource, easily capable (in theory) of providing most of Nova Scotia's electricity needs (Karsten 2013). In addition to power generation, however, there is the prospect of further economic development associated with the skills and materials that need to be developed for tidal energy, some of which could be applied in other countries where marine renewable energy is of increasing interest. Maximising these benefits is potentially a significant contribution to the Nova Scotia economy (OREG 2011; Government of Nova Scotia 2012; Obermann 2013b).

7.13.2 Potential Economic Interactions

The potential interactions associated with economic development in Nova Scotia have been outlined in Jacques Whitford 2008 and ATEI 2013. Jacques Whitford 2008 also includes a long list of potential secondary and tertiary benefits that might accrue as a result of tidal power development in Nova Scotia. Since that document was prepared, interest in tidal energy has grown in many countries, particularly the United Kingdom and France, where government and private sector investments have increased significantly in recent years. Like Nova Scotia, European countries are hoping to play a formative and productive role in the global development of MRE. Several reviews of the various opportunities presented by tidal power testing and development have been completed (e.g. EquiMar 2011a-h; NRCan 2011; Obermann 2013b).

Major areas of economic interaction include the following:

- The need for site-specific environmental assessments, and consequently the appropriate skill sets to undertake these assessments;
- Equipment and facilities for deployment/retrieval of turbines during testing and long term installation, and appropriate skill sets;
- Monitoring services and technologies, including a variety of sensors, remotely-operated-vehicles, wildlife observers, divers, etc.;
- Design and construction of underwater support structures and associated infrastructure, both for tidal stream and tidal range power developments;
- Design and construction of land-based facilities associated with technology construction, vessel operations, power lines, etc.;
- Modification of accommodation and restaurant facilities for the workforce associated with a commercial scale development; and,
- Raw materials (e.g. concrete, rip-rap) and refined products (e.g. metal and composites for turbine manufacture) that will have to be sourced and transported, which might necessitate upgrading and maintenance of roads, assembly areas, etc. These may generate additional environmental issues comparable to other land-based developments.

Tidal lagoon developments will present a variable suite of environmental and economic challenges, depending upon the location and design of each lagoon. Creation of a tidal range project would involve substantial demands for materials for the barrier: large quantities of concrete for all designs, and of rock and aggregate for an offshore lagoon, or steel for the Halcyon approach. These have to be sourced, transported and deployed. Because of the prolonged period required for construction, during which no revenue can be generated from electricity production, financing remains a major hurdle, and the impact upon investments into other sources of MRE, such as tidal stream generation, would be a major consideration.

7.13.3 Economic Planning and Management Considerations

The extent to which Nova Scotia businesses will be able to take advantage of the opportunities raised by tidal power development depends on a number of factors. These include:

- Supply chain adequacy (EquiMar 2011c; NRCan 2011);
- Availability of appropriate materials and/or manufacturing facilities in the province (Obermann 2013b);
- Availability of appropriate skill sets in the province (Howell 2013);
- Ability and/or preparedness of companies to undertake risk (MacDougall 2013); and,
- Financial resources (MacDougall 2013).

The Province of Nova Scotia has committed to support renewable energy through the creation of feed-in tariffs (FIT). A community feed-in tariff (COMFIT) of 65.2 c/KWh was established in 2011 for small scale projects (up to 0.5 MW) that are largely developed by the community (including local investors, municipalities, Nova Scotia First Nations and not-for profit groups). The FIT rate for commercial developments is currently being prepared, and an announcement of the FIT is expected in late 2013. Financial support mechanisms for tidal energy are described in detail in MacDougall (2013), and a case study estimate of costs and benefits of a 5 MW installation is given in Vanblarcom (2013).

8. Cumulative Interactions

Section Summary

This section describes how the cumulative effects of multiple projects on the marine environment are addressed, and outlines the current state of knowledge (and knowledge gaps) on this subject. Cumulative effects are defined, the influence of project scale is described, and the potential interactive effects with other projects in the marine environment are outlined.

8.1 Definition

Cumulative interactions occur when individual impacts from different sources, each generating their own effects, overlap both in space and in time. Cumulative interactions can occur when many TISEC devices are deployed near to each other such that they interact together ("**scaling**" effects) or through the presence of other marine activities or projects located in the same area ("**interactive**" effects). A third form of cumulative interaction occurs when a negative project effect interacts with an existing non-project detrimental effect, which in turn is made even more severe by the two effects together ("**integrated**" effects). As noted in the Background Report to the Phase I SEA, cumulative effects are especially difficult to assess in aquatic environments where projects may create off-site impacts that can be felt over long distances (Jacques Whitford 2008).

It is important to underline that MRE research has so far been limited to the short-term impacts of individual prototype or demonstration-scale devices. As pointed out by Isaacman and Lee (2010).

> "There has [*sic*] yet to be any published models or practical research on the cumulative and synergistic impacts of large-scale TISEC or WEC arrays or arrays in conjunction with other nearby offshore industries…To date, there have been no published studies or models investigating the actual or potential long-term and regional impacts on marine and coastal biodiversity or ecosystem processes due to existing or proposed WEC and TISEC installations."

8.2 Scaling Effects

In some cases cumulative effects may interact in an additive fashion, creating an effect equal to the sum of the individual project effects. For example, the cumulative effect from the vessels used to install five TISECs is likely additive – it is equal to the sum of five individual installations. In other cases cumulative effects may reinforce and magnify each other, creating cumulative effects greater than the sum of each individual effect. For example, the cumulative effect of energy extraction from multiple turbines may be magnified if a 'tipping point' is reached and far field ecological processes are affected.

The assessment of potential cumulative effects also needs to take account of other factors including:

- Method of TISEC connection to the grid (hubs or individuals cables, etc.);
- Configuration of the array: footprint, device arrangements, alignments and spacing;
- Installation, maintenance and decommissioning requirements of multiple units; and,
- Spacing between multiple array developments.

(source: AECOM 2010).

Effects of Energy Extraction

At the most basic level, removing kinetic energy from the tidal stream will reduce the speed of the tidal currents. Although the amount of energy removed by TISECs and the ultimate effects of energy removal are not yet fully understood (and will naturally depend on TISEC type and project configuration), it is expected that changes to current patterns and sediment dynamics, with attendant effects on biological communities, may result. It is also to be expected that any hydrodynamic and ecological effects resulting from a single turbine would be magnified by multiple turbines installed in arrays.

Reducing current velocity will affect the transport and deposition of sediments and alter their properties. The magnitude of these changes, especially in shallow low energy areas (which are of high importance for primary productivity) is not currently known (Van Proosdij 2012).

In Nova Scotia, three-dimensional modeling results suggest that “maximum” energy extraction in the Minas Passage increases tidal elevations and tidal currents throughout the Gulf of Maine and reduces tidal elevations and circulation in the upper Bay of Fundy. Maximum tidal energy extraction in the Minas Passage also has perceptible effects in the density-driven currents and temperature/salinity distributions over the central Gulf of Maine and western Scotian Shelf. With respect to sediment distribution, when tidal energy is extracted from the lower water column (within 20 m from the bottom) far-field changes to bottom sediment properties are noted within the Bay of Fundy (Sheng *et al.* 2012).

The ultimate effects of large energy extraction can be predicted through hydrodynamic modeling, which is becoming more refined as researchers examine the effects of TISECs in tidal streams. To improve the accuracy of these models, additional and detailed current flow measurements are required over the entire water column. These data are usually not gathered until specific sites are chosen for a project. The predictive ability and accuracy of the computer models will then be verified by observations and measurements made once a project is operational.

Effects of TISEC Installation

TISEC installation can disturb fine grained sediments and scour coarser grained materials from the seabed. While this effect may be temporary and limited to the area immediately around a single device, it may also be possible to change the current patterns sufficiently to cause more widespread erosion. This is particularly a risk where underlying fine grained material is protected by coarser sediments at the surface. Once this protective cover is broken by a TISEC device, more extensive sediment transport may result. The presence of multiple devices may worsen this problem resulting in relatively large areas of unstable sediments. Sediment transport itself may have subsequent effects on the biota.

In the situation where a TISEC project is installed in an area of moving bedforms, energy extraction has the potential to reduce current velocities immediately downstream from the installation. The cumulative effect of many TISECs in a localized area may affect the formation and movement of seafloor bedforms, affecting benthic habitat and causing other changes to the downstream ecosystem. Current hydrodynamic models do not provide a definite understanding of the amount of energy that can be extracted before significant changes to sediment pattern occur. At the same time, the effects will be very site specific, related to current and substrate conditions as well as the number, layout and different design characteristics of the TISEC arrays.

8.3 Interactive Effects with Other Projects

The cumulative effects assessment attempts to consider the effects of other past, present and likely future projects and activities in combination with the potential impacts from the specific project being evaluated. During the project design and development stage, proponents of TISEC projects must prepare both a project and site specific environmental assessment (EA) before applying for construction and operating permits. The EA must assess the cumulative impacts of the proposed project in relation to other existing and planned offshore projects in the wider area.

Guidance provided under *CEAA* indicates that "future projects and activities" must have a reasonable likelihood of occurring. For this Report, no specific project is being proposed and so the following sections can only outline the general types of cumulative interactions that may be expected in future MRE project scenarios.

Although it is not possible to describe the likely future projects at this time, the Bay of Fundy has experienced development in the past and will continue to develop into the future. Many of these activities have the potential to interact cumulatively with TISEC projects. Examples of coastal development in the region include:

- Aggregate mining;
- Coastal residential and agricultural development;
- Harbour expansion, harbour dredging, shipbuilding and related activities;
- Bridge and causeway construction;
- Marine resource exploitation;
- Aquaculture operations; and,
- Commercial shipping, fishing, tourism, ferries and other boating activities.

Additional marine infrastructure, such as future telecommunication cables, pipelines and other projects will need to be considered if tidal energy projects are proposed.

Effects of Multiple Types of MRE Projects

Little is known regarding the cumulative interactions of TISEC projects as there have been few projects featuring an array of turbines. In fact, only Verdant Power in East River, NY has installed a small array, and data from this project are limited. No TISEC projects have been installed in close proximity to one another, although the FORCE site may eventually provide some data on multiple technology installations. The presence of a single device is unlikely to have a significant effect on the environment, but the cumulative interaction of industrial farms or arrays may severely impact an area. The results of a 2011 modeling study focused on cumulative impacts of the installation and use of MRE farms (i.e., wind, wave and tidal) suggest a major impact on the environment from these devices (Parscau du Plessix 2011). The principal mitigation measures applied to reduce these cumulative interactions are to ensure that farms are restricted in size (although the size limit is not defined) and that sufficient spaces are left between farms (AMEC 2012).

8.4 Integrated Effects

The assessment of cumulative interactions is further complicated by the complex, dynamic, interconnected nature of marine ecosystems. 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 perturbation (Isaacman and Daborn 2011). Examples of integrated effects are given in the sections that follow.

8.4.1 Natural Cycles and Climate Change

It is well known that the Bay of Fundy ecosystem undergoes significant change over time. Some of these are cyclical (e.g. seasonal, annual or multi-year such as the 18 year cycle of the tides), while others are progressive (e.g. continuing system changes associated with sea level rise, climate change, shoreline erosion, etc.). Over the prolonged time expected for marine renewable energy installations (i.e. decades), such changes have the potential to affect the interactions between TISEC devices and the marine environment. For example, a reduction in tidal energy resulting in decreasing vertical mixing will decrease the introduction of deep cold water, possibly amplifying effects of climate change, or affecting the productivity of fish that appear to be influenced by the 18 year cycle of the tides (e.g. Cabilio *et al*. 1987). A decrease in tidal range caused by energy extraction in Minas Passage as indicated by Karsten (2013), for example, would initially affect intertidal exposure and the flooding frequency of marshes in Minas Basin (cf. Van Proosdij and O'Laughlin 2013). However, because tidal range has been increasing continuously for the last four thousand years or so, eventually the tidal power-induced decrease will be compensated for, although this will take a long time.

Sea level is expected to rise in the Bay of Fundy, due both to projected climate change effects as well as a gradual sinking of coastal regions in response to ice melt following glaciation (Greenburg *et al.* 2012). Although sea level rise may not have direct effects on subsea tidal energy installations, rising sea levels and increasingly severe (and frequent) storms may negatively affect shoreline substations and transmission lines.

8.4.2 Delayed Effects

There is also evidence (e.g. from marine construction – and by analogy, array deployment) that small, possibly incremental changes to critical ecosystem processes may not be evident for a long time after completion of the project, although such changes may well impact critical aspects of the environment (e.g. habitat), or progressively interact with other established resource uses (Isaacman and Daborn 2012). Small incremental changes may not be noticeable until they reach a certain threshold or tipping point or the change may be triggered by a certain event and come on suddenly.

8.4.3 Far-Field Effects

Organisms, water, sediment and energy move between locations and ecosystems. Thus, changes in one location can have effects in another or at a considerable distance from the source. The nature and magnitude of the effects may be different at the local and regional scale. Consequently, consideration must be given to the spatial scale of the cumulative effects assessment. For example, the Bay of Fundy supports many migratory fish species, crustaceans, turtles and marine mammals. Through their seasonal movements, these species form an integral part of marine ecosystems and fisheries throughout different areas in the Bay, the Gulf of Maine and beyond. Thus, the effect of a TISEC development on the species in one area (e.g. mortality, changes in quality or accessibility of feeding or breeding grounds) can affect the overall productivity and availability of these species throughout their migratory route, with subsequent effects on food webs and fisheries.

8.4.4 Ecosystem Interactions

A decrease in numbers of one type of organism or species due to selective mortality or habitat displacement (loss, avoidance, migration barrier) can lead to a cascade effect, with consequences for biological community structure, interactions and food webs and other ecosystem processes (Isaacman and Daborn 2011; Shields *et al.* 2011). In addition to direct effects on species, the loss of or change in habitat can alter the type, quality and abundance of nutrients, predator species, prey (plankton, larvae, invertebrates, forage fish etc,), shelter, and spawning and nursery grounds, with a cascade effect on aquatic ecosystems and populations.

For example, changes in the abundance and diversity of benthic species (invertebrates, algae) can result from changes in physical seabed structure due to reduced hydrodynamic forces and an accumulation of organic matter (Langhamer 2010; Shields *et al*. 2011), or through the 'artificial reef' effect (Langhamer and Wilhelmsson 2009). Changes in habitat structure may favour successful establishment of species that did not previously inhabit the area, with consequent effects on other species and their interspecific interactions. The change in benthic communities can lead to changes in larger species such as fish, crustaceans and marine mammals. Some local species may be attracted to arrays by higher prey abundances and others deterred due to reductions in availability of preferred prey or increases in predators. Conversely, habitat avoidance or mortality may act more strongly on larger, predatory fish or marine mammal species, reducing pressure on prey species (e.g. lobsters) leading to a population explosion. The exact factors affecting the response of biota to TISEC sites are uncertain and may vary by site.

Changes in current energy have variable implications for sediment erosion and deposition patterns, turbidity, nutrients, oxygen and light levels, temperature and flow conditions (Kadiri *et al*. 2011; Shields *et al*. 2011). Changes in pelagic habitat conditions – especially in upwelling areas – can alter the productivity and transport of plankton with possible feedback consequences for water quality (e.g. oxygen levels) and food web interactions.

9. Mitigation and Residual Effects

Section Summary

Mitigation measures are steps taken by project developers that are intended to reduce or eliminate anticipated effects of a project on the environment. These steps may be taken early during the design process, to for example, reduce anticipated noise levels, or later during deployment to, for example, reduce the amount of sediment disturbed during the installation process. A variety of mitigation measures are typically adopted to limited project effects on the environment.

Residual effects, either temporary or permanent, are those effects that remain after all mitigation measures have been taken. This section describes common mitigation measures and anticipated residual effects, based on the project team's best judgement and other marine projects, keeping in mind that no large scale commercial arrays have yet been deployed.

9.1 Overview

As noted, TISEC projects are, to a certain degree, similar to other large projects in the marine environment such as bridges and offshore oil drilling platforms. In all cases, project activities associated with construction, operation and removal or decommissioning have the potential to impact marine ecosystems and organisms, both at local (near-field) and regional (far-field) scales. With respect to TISEC projects, typical issues of concern include changes in physical processes (current and sediment transport regimes), alteration and loss of habitat, contaminants, electromagnetic fields, noise and vibrations and the physical interaction between TISECs and fish, birds, marine mammals and other organisms.

During the project design and development stage, proponents of marine construction projects must prepare a site- and project-specific environmental assessment (EA), which considers the potential environmental effects of the project through the installation, operation and decommissioning phases. The EA predicts likely environmental effects, evaluates their relevance, identifies mitigation measures, assesses residual effects and identifies monitoring requirements to quantify residual impacts (EMEC 2009).

Residual effects refer to the environmental impacts remaining after mitigation, taking into account background environmental conditions. That is, it is assumed that certain effects can be mitigated (avoided or minimized) using both adaptive and standard management practices, while other impacts – the residual ones - cannot be fully mitigated. Some residual effects may provide positive benefits and do not need to be mitigated. Mitigation includes project design, environmental protection strategies, and mitigation practices aimed at reducing or controlling potential adverse environmental effects on valued ecosystem components. As required by *CEAA*, these measures must be technically and economically feasible. Depending on the anticipated environmental effects, mitigation strategies are optimized to minimize adverse environmental effects and enhance those effects that may have positive benefits.

Tidal energy projects must be constructed, operated and decommissioned in accordance with applicable legislation, permit conditions and accepted industry best practices. Some of these measures are inherent in project design and represent standard practices for subsea infrastructure, such as the use of biodegradable lubricants and non-toxic antifouling coatings. In most cases, mitigation measures are described at the EA stage of project development, once a particular project has been described in detail and its biophysical and economic impacts are generally known. Once a specific project has been proposed, the environmental effects, mitigation measures, operations and maintenance procedures and monitoring plans can be described by the developer's team, presented to residents and submitted for approval to the regulators.

The mitigation measures and residual effects described below touch on some of the subjects that would be described during the EA phase of a tidal energy project.

9.2 TISEC Construction and Decommissioning

Typical residual environmental and economic effects during construction and decommissioning may include:

- Limited direct mortality of some slow-moving or immobile flora and fauna;
- Permanent alteration of a small area of habitat in the immediate project footprint;
- Temporary degradation of habitat (water) quality through an increase in turbidity;
- Temporary noise from turbine device and cable installation and the presence of boats and other equipment;
- Impacts from activities associated with the construction of the cable corridor and land-based facilities (i.e., clearing and grubbing);
- Fishers in the area may have access to traditional fishing areas restricted due to safety exclusion zones, loss or damage to gear or due to increased vessel traffic associated with project activities; and,
- Similarly, tourist and recreational users of the project area may as well be restricted.

Mitigation measures to avoid or limit construction / decommissioning impacts resulting in residual effects may include:

- Obtaining *Fisheries Act* Authorization, if required, to minimize loss of fish habitat and create new habitat if required;
- Limiting use of artificial lighting to only what is required for safe operations during construction / decommissioning;
- Limiting equipment travel and repair any damage caused by equipment travel;
- Minimizing project footprints. Restoring to pre-construction conditions to the extent possible;
- Maintaining slow, constant vessel speeds to minimize potential for collisions with mammals and marine birds;
- Limiting the approach distance to marine mammals;
- Establishing a safety exclusion zone around MRE devices;
- Undertaking installation and removal activities outside of lobster fishing season to the extent possible. Seasonal constraints may also apply to certain species of fish, birds and marine mammals;
- Where activities are required during the lobster season, informing fishers of vessel movements, timing and locations;
- Operating vessels in specified routes and locations;
- Providing fishers with coordinates of subsea cable and turbines;
- Stopping work and contacting the Nova Scotia Museum upon discovery of archaeological or heritage resources;
- Undertaking archaeological monitoring during ground disturbance and trenching / excavating; and,
- Placing cables on stilts during the cable pull to minimize disruption of habitat; completing the cable installation at low tide in one day. Directional drilling may also be considered.

9.3 TISEC Operation and Maintenance

Turbine operation could potentially result in:

- Changes to current velocity in the immediate vicinity of the structure affecting the scour, transportation and deposition of sediments;

- Changes to the patterns of sediment distribution, which in turn may have environmental effects on marine communities;
- Marine species mortality from collisions with turbine structures or if there is a sudden pressure drop as the individual proceeds through the device;
- Increases in biological productivity associated with new habitat: fixed structures typically become a focus for biological production, which further attracts marine life. In some cases, structures can provide alternate habitat, which may be considered beneficial if these structures provide habitat diversity which may in turn increase species diversity in the area. Alternatively, species may experience very limited behavioral changes such as avoidance and aversion due to the presence of structures; and,
- Noise and vibration effecting changes in the behavior of marine organisms.

Mitigation measures to avoid or limit operational impacts resulting in residual effects (in addition to those described above for the construction / decommissioning phase) may include:

- Develop and undertake noise monitoring for each turbine as well as for potential cumulative effects of all turbines together for an array;
- Monitor changes to benthos at the turbine device(s) through follow up video surveys. Other monitoring surveys (birds, mammals and fish) may also be required.
- Undertake maintenance activities outside of lobster season to the extent possible. Where activities are required during the lobster season, inform fishers of vessel movements, timing and locations; and,
- Design and implement lobster surveys in cooperation with fishers to identify any changes in catch size.

When EA approval is granted for a particular tidal energy project, the consenting authorities typically specify terms and conditions of approval as well as monitoring requirements needed to effectively manage residual effects . In many cases, adaptive management itself is the best approach to mitigating effects (e.g., scheduling around fish migrations). A key factor for adaptive management may be restricting the initial development size (e.g., to 5 or 10 turbines) and allowing only incremental increases in development scale once it can be demonstrated that no adverse effects on sensitive species have occurred. This approach is consistent with recommendations made in the 2008 Bay of Fundy SEA.

ORPC's 2012 Environmental Monitoring Report for the Cobscook Bay Tidal Energy Project describes how an Adaptive Management Plan was used to advance new hydrokinetic technology while minimizing the potential for environmental impacts. Where deficiencies in monitoring equipment and methodologies were identified, ORPC engaged Stakeholders (e.g., technical advisors, consulting scientists, manufacturers) to troubleshoot issues and develop improvements. As a result of monitoring, which indicated no observed adverse interaction with the marine environment, the understanding of the appropriate level of environmental monitoring has improved (ORPC 2013).

Similarly, in 2011 MCT released its SeaGen Environmental Monitoring Programme Report for its Strangford Lough project. By taking into account the increased scientific knowledge built up through ongoing monitoring, the establishment of an environmental baseline against which all future monitoring could be compared, and the adaptive management approach adopted by MCT, subsequent variations of the conditional marine construction license have been issued to MCT since 2005. Monitoring results provided evidence to support the reduction in mitigation requirements and confidence that SeaGen can continue to operate with no likely significant impacts on the marine environment in Strangford Lough (MCT 2011).

9.4 Tidal Lagoons

Two concepts have so far been proposed for tidal lagoons to be constructed in the Bay of Fundy. One approach envisages creating an offshore or shore-based lagoon in shallow waters of Minas Basin through construction of a dyke composed of concrete caissons (to house turbines and sluices) and extensive lengths of a rubble mound; this approach has been examined by Cornett *et al.* (2011). The other approach entails a shore-based lagoon at Scots Bay enclosed behind a wall of thin concrete panels held by steel I-beam pilings drilled into the substrate, with concrete caissons housing turbines and sluices (Halcyon 2012). The first approach is restricted to shallow waters because of the exponential increase in material required as depth increases, whereas the piling-panel design would enable construction in deeper waters. The footprint of the latter enclosure is relatively independent of water depth, but the footprint of the former approach expands dramatically with depth. A final difference between the two approaches is that the piling-panel design is potentially almost completely removable, by floating out concrete panels and cutting support pilings off at the seabed; it is highly improbable that a long rubble-mound dyke would ever be removed, even if it was found that such a tidal generation lagoon was undesirable.

The tidal range approach involves capturing a large fraction of the *potential energy* of the water held within the impoundment. In either case, lagoon tidal power installations have the potential for substantial changes to the ecology not only of the immediate area, but much further afield.

The environmental effects of the Halcyon (2012) proposal for Scots Bay have not been examined yet, but Cornett *et al.* (2011) examined the effects of several scenarios (varying in size) of the rubble-mound concept, as well as a scenario involving more than one lagoon on the hydrodynamic properties of the Bay of Fundy. As expected, the models indicate that the hydrodynamic effects increase with increasing size and number of lagoons, but that even the smallest scenario would be expected to produce effects over the whole Bay of Fundy/Gulf of Maine system. For example, a single 24 km^2 lagoon in Minas Basin would increase the tidal range at Boston by ~1.4 cm, and a combination of 6 lagoons would increase it by an estimated 5.5 cm. Local effects in Minas Basin are somewhat larger: up to a 12 cm *decrease* in tidal range in Minas Basin outside the lagoon. While these changes seem small relative to the existing tidal range, the non-linear relationships between tidal range and ecosystem processes such as sediment resuspension and deposition, vertical mixing, wave generation, scouring and shoreline erosion require careful consideration. In addition, the limited capacity of sluice gates, even when combined with turbine sluicing, means that tidal range within the lagoon will be substantially less than before the enclosure, resulting in a loss of intertidal zone that may have important ecological consequences.

The loss of intertidal zone is avoided in the Halcyon (2012) proposal by alternatively pumping water into the impoundment at the end of the flood tide so that water levels reach the pre-existing high water mark, and pumping water out of the impoundment on the later part of the ebb tide to reach the pre-existing low water mark. (Because the amount of electricity generated in a tidal range scheme is crucially dependent upon the head of water, the electricity expenditures associated with pumping may in fact be more than compensated for by the increased power output during generation).

Residual effects from tidal range approaches would be of considerable concern. As Cornett *et al.* (2012) found, even the smallest lagoon considered would have measurable effects on tidal range as far away as Boston. Given the non-linearity of the relationships between tidal range, current flows, mixing processes and biological productivity, any changes over such large portions of the system would have to be carefully evaluated. In addition, the life-time of a tidal range installation is commonly suggested as 100 years or more, so that the physical dynamic changes would be extensive in time. Although not entirely equivalent, examination of tidal barrages in the Bay of Fundy have shown that not only are the effects on sediment deposition and erosion non-linear, but some of those important ecosystem changes may not be detectable for years, by which time the rate of change may have become extremely rapid.

Environmental effects of tidal range lagoons have been outlined above. They include:

- Changes to tidal range, current flows and direction, tidal phase, etc., perhaps over much of the Bay of Fundy and Gulf of Maine;

- Entrainment and direct mortality of fish, some of commercial importance, and possibly of mammals trapped within the lagoon;
- Wholesale changes to benthic conditions within the impoundment, leading to substantial changes in benthic organisms and productivity;
- Permanent trapping of sediment within the lagoon;
- Loss of intertidal habitat;
- Possible loss of peripheral salt marshes and productivity;
- Scouring of substrates downstream of turbines and along the sides of the impoundment;
- Change in clarity of water and therefore water column productivity;
- Increased opportunities for aquaculture and/or recreation (possibly limited by contamination issues); and,
- Possible synergistic opportunities for other renewable energy sources such as offshore wind and solar power.

Critically, however, the long term implications of lagoon structures and operations means that these effects will continue over a very long time, and may be extremely difficult to mitigate.

10. Area Use Conflict Mitigation

Section Summary

Overlapping interests in a given marine space by different users (e.g., fishers, tourism operators, project developers, etc.) are not necessarily conflicts since many marine uses can co-exist with deeply submerged TISECs. Nevertheless, most types of industrial projects occupy space and consume resources that cannot otherwise be used by others. In general, three types of conflicts can be identified: (a) project area use conflicts, (b) equipment resource availability conflicts and (c) the presence of protected ecological and cultural areas. These types of conflicts are not restricted to tidal energy projects alone but apply to varying degrees to most large marine infrastructure projects. This section describes these potential conflicts in more detail, and presents some approaches to resolve or accommodate competing uses.

10.1 Project Area Use Conflicts

Potential marine area use conflicts are common to all types of MRE projects since these projects occupy portions of the seabed and water column used by others, employ vessels during installation and maintenance, and may represent impediments to navigation and safe anchorage. At the most basic level, the presence of a tidal energy project may prevent others from using the project area for other purposes. Other potential marine uses in an area where a tidal project may be deployed may include:

- Commercial, recreational and subsistence fishing;
- Commercial and military shipping through the site;
- Recreational boating;
- Recreational diving or swimming;
- Tourism, whale and bird watching;
- Oil and gas exploration and project infrastructure;
- Aquaculture installations;
- Mining and aggregate extraction;
- Telecommunication/electrical cables and pipelines; and,
- Other alternative energy projects.

Although some potential conflicts can be avoided during site selection, other conflicts with commercial and recreational users cannot always be avoided since these activities occur in most marine coastal areas. Some restrictions may be imposed to limit public access and ensure safety and it is reasonable to assume that larger projects will require larger restricted areas. Project developers may wish to restrict as large an area as possible to ensure the safety of MRE infrastructure (especially vessel safety during TISEC installation and maintenance); however, all marine vessels, both commercial and recreational, must also be able to safely drop anchor in the event of an emergency while navigating in the vicinity of MRE projects.

The establishment of safety exclusion zones will likely be necessary to protect both project infrastructure and other marine users. However, by excluding certain areas from economic use, displaced users may be pushed from their preferred use areas on to the preferred areas of others, crowding and lowering the take for each user and thereby lowering the gross income of the area. Fishers displaced from productive nearshore areas may have to travel further from their home ports in order to collect the same harvest, increasing travel time, fuel costs, wages, repair requirements, and safety concerns. On the other hand, exclusion zones may act as fish nurseries and refuge zones, in turn increasing harvests in the vicinity. The subsea infrastructure associated with tidal energy projects may provide habitat for mussels and seaweed which in turn can provide food and shelter for certain fish species and/or their prey.

Where tidal energy project sites overlap with fishing grounds, fishers may expect compensation for any loss of gear associated with the project, but typically no reverse compensation is made for loss of project-related research / monitoring equipment to fishing activity. In the Bay of Fundy, Digby Gut is used by numerous lobster fishers and the Grand and Petit Passages are trawl fishing areas. Due to the strong currents, no net fishing is known to occur in Minas Passage or Minas Channel although lobster fishing is practiced in nearshore areas. It is in the best interest of developers to site MRE projects and monitoring equipment outside of heavy fishing areas, particularly where monitoring equipment may be located outside of project safety exclusion zones.

As the proponent for three COMFIT sites in the Digby region, Fundy Tidal's approach to potential area-use conflicts and stakeholder engagement is a combination of formal and informal processes. For their Digby Neck projects, Fundy Tidal established the Islands Tidal Power Advisory Group comprised of representatives from the fishery, port authority, local and municipal government, development associations and businesses. This group meets on a monthly basis. With respect to the COMFIT project in Digby Gut, the company meets regularly with the Digby Industrial Commission, the Town of Digby, Municipality of Digby, Port of Digby and local fishermen.

Informal discussions with local fisherman and tourism operations have been ongoing throughout project development, facilitated mainly through engagement in research and development activities, and the presence of Fundy Tidal staff in the project communities.

Fundy Tidal has been active in developing an understanding of community engagement requirements and best practices. Fundy Tidal worked with ATEI to develop the *Community & Business Toolkit for Tidal Power Development* (ATEI 2013) and the *Tidal Energy Community Engagement Handbook* (Issaacman and Colton 2013). Fundy Tidal led the community engagement component of the *Southwest Nova Scotia Tidal Energy Resource Assessment* project which included meetings in Digby, Yarmouth, and Shelburne counties and included the participation of five municipal governments as well as the villages of Tiverton, Freeport and Westport. Individual and small group meetings were conducted with Port Authorities, local fisherman, the Coast Guard, whale tour operators and representatives from local boards of trade. Consultation and engagement is ongoing for these COMFIT projects.

10.2 Safety Exclusion Zones

As submerged, moored or surface-piercing infrastructure, tidal devices represent a potential risk to other vessels and water born organisms during their construction, operation, maintenance and decommissioning. This risk may take the form of collisions or navigational hazards with installation/maintenance vessels, the device or its mooring cables, or entanglement of fishing lines, nets, traps, or anchors with the device, its mooring lines or subsea cables.

To reduce this temporary risk during construction and maintenance, project operators in collaboration with Transport Canada establish a temporary safety zone around the work area for the duration of the work. The size of the safety zone will vary depending on the work to be undertaken, depth, current and tide conditions and other factors; 300 m was used at the FORCE site during installation of the OpenHydro TISEC, while EMEC maintains a 500 m exclusion zone (I. Bell, pers. comm. 2013). Exclusion zones are established on a case by case basis.

In Canadian offshore waters, Transport Canada is responsible for regulating navigational hazards through the *Navigable Water Protection Act*. Transport Canada issues permits for installations in all navigable waters, both fresh and marine. In contrast, Transport Canada does not establish or impose permanent safety zones or marine exclusion areas. The Department of Fisheries and Oceans Canada (DFO) through the Canadian Coast Guard is responsible for ensuring mariners are aware of submerged or moored infrastructure such as MRE devices. Immediately prior to deployment the project proponent is required to post "no anchorage" signs and issue, through the Coast Guard, a notice to mariners indicating the location and nature of the hazard. The notice to mariners is posted on the Coast Guard Notices to Mariners (NOTMAR) website. The website allows interested parties to update their navigational charts and publications with the latest information regarding navigational hazards.

DFO may establish a permanent marine exclusion area, but only for specific purposes. A marine exclusion area may be established to keep mariners (including fishers) away from a contaminated site (for example, an exclusion zone was established around the Irving Whale shipwreck area) or for wildlife protection purposes (for example to protect spawning grounds of a rare species). All other safety or exclusion zones, including those that may be suggested around operational tidal energy projects, are established jointly by the project proponent and local users of the area.

Project boundary markings and navigational alerts will be established through discussions and submissions by the project proponent to Transport Canada. As noted, neither Transport Canada nor Fisheries and Oceans Canada can establish permanent exclusion zones for tidal energy projects. Negotiations regarding temporary and permanent access limitations are held between project proponents and other area users with interests in the project site. These people may include finfish and shellfish harvesters, marine transporters, Mi'kmaq peoples, tourism operators, recreational boaters and in some cases, coastal residents. Given the number of users and interests in the region, project proponents should anticipate early and on-going consultation throughout the project preparation phase so that conflicting interests can be identified and competing claims resolved prior to deployment.

10.3 Resource Availability Conflicts

In contrast to the predominantly positive economic benefits the tidal energy industry may bring to Nova Scotia (section 2.11), certain potential economic drawbacks must also be considered. Large industrial projects established outside of historically industrialized areas have a tendency to utilize, and to a certain extent monopolize, limited local resources and services. Where more than one such project may be under construction at the same time, for example an offshore drilling program and a TISEC array, competition for available resources may result.

With respect to marine services in Nova Scotia, multiple projects may result in shortages of tugs, transport and jack-up barges, cable laying vessels, skilled mariners, trained pilots, etc. On land, competition for wharf space, laydown and assembly areas, cranes, warehouses, trucking and rail services may occur. Shortages can lead to project delays and increased project costs.

In addition, there is a tendency for the demand at different projects to occur at the same time. Should tidal arrays be proposed in Minas Passage for example, services and infrastructure needed for deployments, maintenance and recovery will be greatest during neap tides when the tidal range and current speeds are reduced and periods of slack tide are longer.

Finally, local governments have multiple investment priorities and limited investment resources. The tidal energy industry will inevitably require investment in infrastructure and training that, under other circumstances, might be invested elsewhere for the benefit of other industries. The competition for local investment must also be considered by project developers, governments and residents as the tidal energy industry moves forward in Nova Scotia.

10.4 Protected Ecological and Cultural Areas

Certain areas of the Bay of Fundy area are afforded a level of protection or have limitations on their use given their ecological or heritage significance. In some cases, these areas may conflict with tidal energy project development due to their protected or restricted use status. In other cases, species may need to migrate through a project area on its way to a protected spawning or rearing area. Sensitive or protected areas may include:

- Conservation areas such as parks, waterfowl reserves, and marine protected areas;

- Environmentally sensitive or unique areas;
- Marine archaeology sites; and,
- First Nation sacred spaces or harvest areas.

There are a considerable number of internationally, nationally and provincially protected or designated ecosystems within the Bay of Fundy that must be considered when planning for future TISEC project developments. In addition, there are numerous national and provincial parks and historical sites, as well as areas recognized or protected by other groups, such as Ducks Unlimited, the Nature Conservancy of Canada, and private individuals (Figure 35). These include, but are not limited to:

- UNESCO **Fundy Biosphere Reserve**;
- **Ramsar** sites (i.e., sites recognized by the Convention on Conservation of Wetlands of International Significance) in the Upper Bay of Fundy;
- **National Migratory Bird Sanctuaries** (NMBS) in Amherst Point and Kentville;
- **National Wildlife Areas** (NWA) in the Chignecto-John Lusby Marsh and Boot Island located on the Avon River estuary in Minas Basin;
- National Historic Sites (NHS);
- Wilderness areas, Ecological Reserves, Conservation Areas, Game Sanctuaries or Wildlife Management areas;
- **Nature Conservancy of Canada** (NCC) ecologically important sites on Spencer's Island, Economy Point, Long Island, Peajack Road (Brier Island) and Gull Rock (Brier Island);
- **Nova Scotia Nature Trust** (NSNT) properties within the Fundy watershed, including the two Brothers Islands near Parrsboro; and,
- **Musquash Estuary Marine Protected Area**, located in the Bay of Fundy approximately 20 km southwest of Saint John, New Brunswick.

The Nova Scotia Department of Natural Resources maintains the Restricted and Limited Land Use database (http://www.gov.ns.ca/natr/forestry/rlul/download.asp). The database lists the spatial boundaries of protected or limited use land designated for conservation, ecological, resource management, or heritage purposes and has an on-line viewer that identifies each of these areas. Other areas of particular interest are described below.

North Atlantic Right Whale Critical Habitat

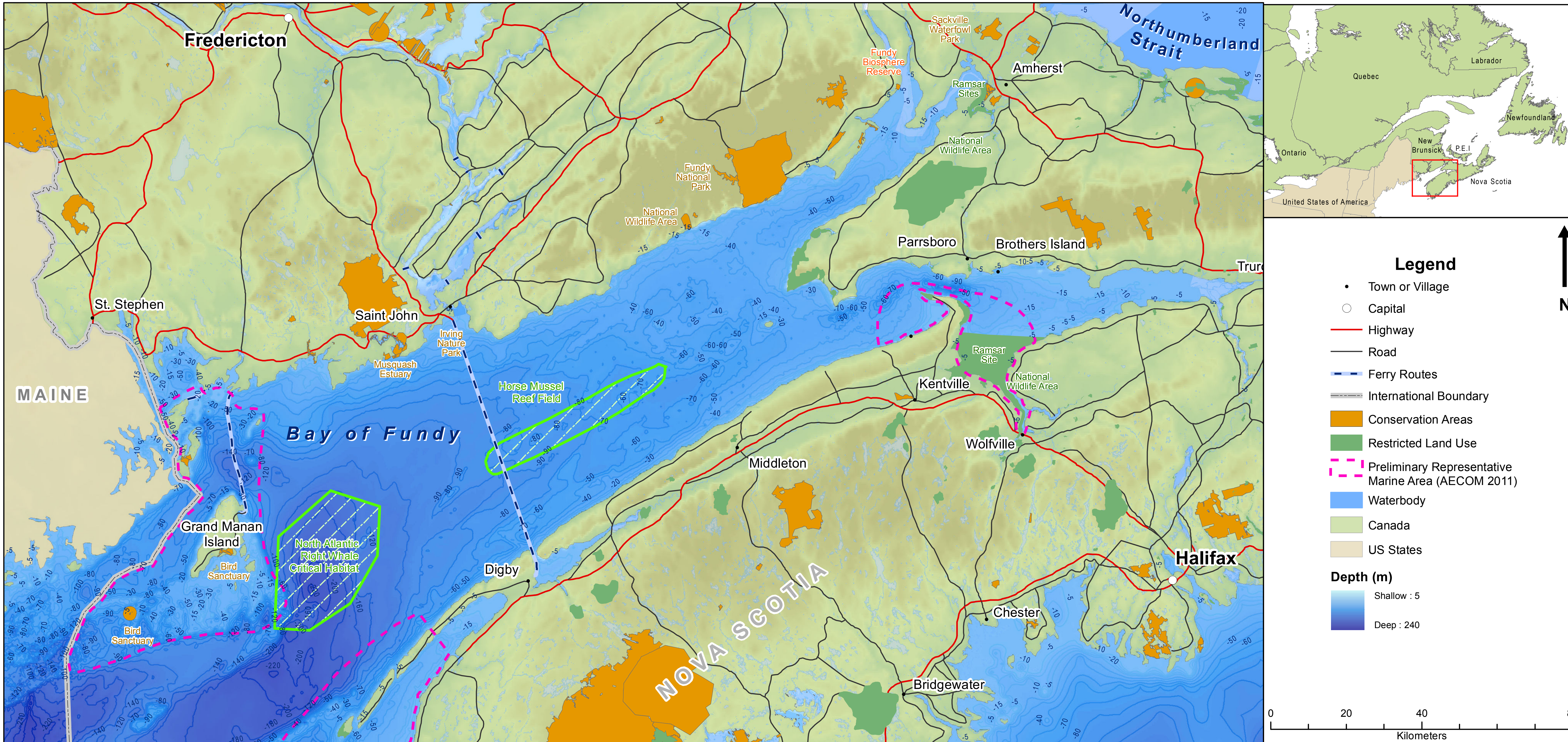
The right whale critical habitat zone in the Outer Bay of Fundy was initiated by the Canadian Coast Guard in 1993 as a Notice to Mariners primarily to help reduce collision risk between right whales and vessels en route to and from Saint John, NB. In 2003, the shipping lanes in this area were changed to further avoid an area east of Grand Manan Island where this species congregates. The habitat covers a 740 km^2 area midway between Digby Neck, N.S., and Grand Manan. There are about 300 North Atlantic right whales and each year from June through December, as many as 50% of these congregate in the southern part of the Bay of Fundy to mate, nurse their young and to feed on the available plankton. This area is not a designated sanctuary as such, but it is listed as Right Whale Critical Habitat under the federal Species at Risk Act (SARA). While not explicitly protected under SARA, the habitat is part of an Environment Canada-led recovery strategy for that species (D. Fenton, pers comm. February 2011).

Trinity Ledge Herring Spawning Area

The Trinity Ledge Herring Spawning Special Management Area, located in the near offshore just north of Yarmouth, NS has been the subject of a new herring management regime by DFO fisheries biologists since 1993. Herring fishers have voluntarily adopted a "survey, assess, and then fish" protocol. Fishers in conjunction with DFO conduct a survey based on a predetermined grid, and transmit the information to a management committee which estimates the biomass present. The committee then recommends a harvesting level (usually 20% of the observed biomass) in that area, keeping in mind the total allowable catch for the commercial fishing season. Equally as important, the Trinity Ledge Spawning Area is generally closed to commercial fishing during spawning season, from mid-August to mid-September, although the timing may change from year to year (Fisheries and Oceans Canada 2005).

Ecological and Biologically Sensitive Areas

Canada's Oceans Act authorizes DFO to provide enhanced protection to areas of the oceans and coasts which are ecologically or biologically significant. In 2004, DFO developed national criteria for Ecologically and Biologically Significant Areas (EBSAs) that provide consistency in evaluations (DFO 2004). Buzetta and Singh (2008) identified a list of EBSAs for the Bay of Fundy and approaches and recommended the establishment of three EBSAs: Head Harbour / West Isles / Passages, The Wolves, and Maces Bay. These areas are located in the Passamaquoddy Bay area of the Bay of Fundy.



Bay of Fundy

Protected & Significant Areas

September 2013	1:1,000,000	Datum: NAD83 Zone 20 Source:
P#: 60290436	V#: 003	

AECOM

Figure 35

Summary

There are examples of tidal energy projects operating within ecologically protected zones, including Clean Current's installation at the Race Rocks Ecological Reserve in British Columbia, and MCT's installation in the Strangford Lough Special Area of Conservation, Northern Ireland. These projects suggest that TISEC installations can co-exist with ecologically protected use areas under certain conditions. MRE projects within or in close proximity to ecologically or culturally significant sites must be evaluated on a case by case basis and may ultimately be refused development permits. If approved, specific mitigation and monitoring measures will likely be required. Coastal zone planning may be helpful to avoid siting TISCEC projects near areas of particular ecological or cultural interest.

10.5 Conflict Mitigation and Resolution

Local exclusion zones and access restrictions require Transport Canada and DFO review, but area use *discussions* are primarily restricted to project proponents and those marine users with direct and ongoing interest in the project area. Conflict with other resource users, residents and interested stakeholders can also be addressed through clear coastal management policies developed in collaboration with local and regional resource users. These policies are typically developed in advance of MRE projects, allowing time to identify potential conflicts and establish consultation mechanisms to document coastal uses, sensitive areas and stakeholder interests. The Strategic Environmental Assessment is one type of policy tool used for this purpose. Space-use conflict may also be addressed through Integrated Coastal Zone Management (ICZM) or Integrated Coastal Management (ICM), or other stakeholder consultation programs.

ICZM and ICM are high-level, comprehensive planning tools that identify conflicting uses and establish governance processes to ensure that any development plans for contested areas are integrated with existing environmental and social goals and are made with the informed input of those people affected by the development. In the Bay of Fundy, examples of past integrated management initiatives include: Upper Bay of Fundy Pilot Management Plan, Annapolis Basin Clam Management Board, Bay of Fundy Fisheries Council, Southwest New Brunswick Integrated Planning Process, Sustainable Communities Initiative, and the Minas Basin Working Group (Graham 2008). At this time, no ICZM programs are planned for the Bay of Fundy, although such a program was included as a recommendation in the 2008 SEA.

Marine spatial planning has been used in the UK to identify issues and interactions between MRE projects and other users, establish area use priorities and provide regional locational guidance for different types of MRE projects (AECOM 2011b; Alexander *et al.* 2012). Marine spatial planning is a well-established process that identifies:

- The long term vision of each marine sector in a region;
- The likely interactions or conflicts with other sectors that may need to be addressed in order for growth to be achieved; and,
- Consultation mechanisms to enable issue resolution.

As in most other large projects touching multiple stakeholders, early and ongoing communication and consultation, combined with project-specific environmental impact assessments, which require additional consultation, are fundamental methods used to identify potential conflicts. The ultimate mitigation measures aimed at resolving user space conflicts and reducing impingements on other activities are best arrived at through a collaborative, multi-stakeholder process.

11. Data and Knowledge Gaps

Section Overview

Although much research has been initiated in the last five years to address the environmental implications of tidal energy development in the Bay of Fundy, the assessment of risk is still hampered by limitations in knowledge and data. One of the main reasons for our limited understanding of the environmental effects of TISECs is the lack of functioning turbine arrays where these effects can be measured or modeled. This section summarizes the knowledge gaps with a focus on the Bay of Fundy, and to the extent currently possible, makes recommendations to address them.

11.1 Knowledge of the Existing Environment

Since 2008, monitoring and site investigations in the Minas Passage and Channel area have provided a more complete understanding of current flows, bottom characteristics, and biological phenomena. Nonetheless, there remain a number of uncertainties that need to be resolved in order to improve the accuracy of environmental predictions:

1. **Tide Gauging**. Numerical models have been developed to assess more accurately the size of the resource, and to forecast the effects of energy extraction, but these models depend upon validation against long term measurements of tidal range, current velocity profiles at various locations and depths in the Channel and Passage, and measurements of turbulence. Some of these measurements are being provided by FORCE-sponsored projects. Until very recently, there was only a single tide gauge in the whole of the Bay of Fundy (at Saint John), which severely limited the refinement possible of the models. To address the need for greater accuracy in tidal range for the Minas Passage, a tide gauge was installed at the FORCE site in mid 2013.

   Recommendation: Long term tidal data, similar to that collected at the FORCE site, should be collected for the future tidal energy sites along Digby Neck.

2. **Turbulence**. The turbulence regime is a major uncertainty at all potential TISEC sites. Knowledge of turbulence is critical both for understanding the stresses on marine infrastructure and for forecasting the effects of tidal extraction on the benthic boundary layer, vertical mixing and air bubble entrainment, and the fate of suspended sediments. Research under way at both FORCE and the Southwest Nova Project (FORCE 2011; Trowse *et al.* 2013b) is steadily improving that knowledge, but it remains a limitation. Additional research on turbulence is currently being undertaken by Dr. Alex Hay in both Minas Passage and Grand Passage. The results of this work are expected to be published in 2013. Additional information on this research can be found on the OERA website at http://www.oera.ca/marine-renewable-energy/tidal-research-projects/hydrodynamic-modeling/.

   Recommendation: Research on the subject of turbulence should continue in an incremental fashion so that potential far field and cumulative effects can be more accurately modeled.

3. **Fisheries**. Knowledge of fishery activities is limited in all regions of the Bay for several reasons: fishers are not required nor are willing to declare precise locations of operation; data collected by authorities have mostly been collated as to point of landing and are not easily de-aggregated to provide a real estimate of fishing activities in any particular locality; and fishers only report commercially targeted species (plus certain by-catch for species of conservation concern). DFO has begun to rework more recent data as part of its spatial planning initiative, but the level of resolution is still very coarse. More detailed, site-specific information would be extremely useful to help determine the magnitude of impacts from displacement and exclusion so these impacts can be mitigated and potentially compensated. Research and record keeping would be helpful to document the number of boats,

locations and harvest statistics at future MRE project sites. Attempts to enlist fishers in the research have had some success (e.g. the newly-instigated weir monitoring project of FORCE), but direct knowledge of fish stocks and fishing activities at TISEC sites remains inadequate. It is critical to continue to build confidence among fishers that sharing of information will not in itself compromise their activities in the future.

Recommendation: The Province, in discussions with fishers' associations, DFO and other groups should develop and implement a record keeping system that will allow an accurate understanding of fishing pressure at potential tidal energy sites.

4. **Fish Presence**. Knowledge of fish use of and movements in the Minas Passage area has increased because of the application of tagging studies. At all sites being considered for TISEC development, however, it is critical to obtain more detailed information about exactly where and when different species occupy or transit through the site. Present acoustic technologies have proved effective in Cobscook Bay (Maine), where conditions are similar to those of the Digby Neck passages, but so far have had limited success in imaging fish groups in Minas Passage when deployed at the surface. These technologies might function adequately if bottom-mounted in Minas Passage, but further research and development is needed. It is anticipated that all TISECs deployed at the FORCE site will incorporate acoustic fish monitoring devices, but the present challenge is adequately establishing pre-deployment use by fish. In the event that the FAST project is not completed prior to the first deployment of a turbine, it will be necessary to deploy acoustic sensing technologies in order to monitor fish movements through the area.

   Recommendation: The tagging program currently under way should be continued to provide more complete information regarding the three selected species: striped bass, Atlantic sturgeon, and American eel. Similarly, any development of a tidal lagoon will require evaluation of the extent of fish use of the proposed development site, which currently is entirely lacking. Further research and development is needed to refine bottom-mounted devices capable of detecting fish near turbines.

5. **Fish Habitat**. Fish habitat is still inadequately characterized in the proposed TISEC sites along Digby Neck.

   Recommendation: An assessment of fish habitat type and productivity should be undertaken during the project-specific environmental assessment prior to TISEC deployment.

6. **Benthos**. The marine benthos is inadequately known in the Outer Bay. Video and/or diver observations should be incorporated in future studies. Tests of multibeam bathymetry as a means of documenting seasonal and other change in benthic habitats (cf. Brown *et al.* 2013) will provide information on benthic habitat, particularly where substrates are covered by mobile deposits.

   Recommendation: Bathymetry surveys of the areas adjacent to future TISEC deployment sites are recommended. This technique should prove useful for preliminary assessment and for monitoring changes in benthic habitat within and surrounding any tidal range development that is planned.

7. **Marine Mammal Use**. The high priority concern over marine mammals requires better information on marine mammal use of TISEC sites. Technologies currently being tested, such as C-POD and icListen hydrophones, appear effective at recording the presence of cetaceans such as porpoises and dolphins. These devices may not be so useful for other whale species which produce very different sounds that may be more difficult to discriminate from ambient noise. Observer-based monitoring should remain an important, cost-effective, technique until more automated technologies are available that will also give information on marine mammal movements when the animals are submersed, and hopefully provide information on the behavioural responses of mammals to the presence of operating TISEC devices.

Recommendation: The use of C-POD and icListen devices to monitor porpoises and dolphins should continue and if possible, be expanded to areas of tidal energy interest that are not currently being monitored.

8. **Marine Mammal Interactions**. While the evidence is that marine mammals are able to avoid contact with large, immobile, marine infrastructure, there is compelling evidence that cables and nets used in connection with aquaculture, lobster- or fin-fisheries, represent a distinct hazard. Some of the TISEC deployment strategies that have been proposed involve tethering to one or more anchor points by cables that may be essentially undetectable. This is an issue that needs to be evaluated both where it is used for tethering a turbine and where safety exclusion areas are to be marked by buoys, etc. It may well be necessary to adopt deterrent devices, similar to those used to deter seals from aquaculture sites, where undetectable mooring strategies are used in areas of cetacean occurrence. (See note 9 below).

   Recommendation: Considerable additional study is required to assess whether technologies that are tethered by anchor cables within the water column can be avoided by marine mammals. Exploration of potential options for deterrence should be undertaken before turbines are installed.

9. **Noise and EMF**. Limited knowledge exists of the effects of noise and EMF from the installation and operation of devices/arrays on marine mammals and fish including increased risk of barrier effects, habitat exclusion and species displacement. Recent literatures reviews on this subject are found in Frid *et al.* (2012) and Normandeau *et al.* (2011).

   Recommendations: Monitoring and in some cases modeling should be used to determine:

   - Ambient (background) noise levels prior to deployment;
   - Noise levels generated from operational tidal devices;
   - Effects of noise on sensitive receptors such as marine mammals and fish;
   - Whether noise levels are causing barriers to movement for certain species along migratory routes and transit pathways; and,
   - Whether noise from devices is leading to habitat exclusion or species displacement.

   Data can be collected from monitoring/research programs of offshore wind developments (UK and Europe) to establish:

   - Noise levels generated during pile driving;
   - Effectiveness of mitigation measures to reduce noise levels;
   - Effect of noise from piling on sensitive receptors (e.g. marine mammals and fish);
   - Whether noise from piling activities associated with large wind farms is creating barriers to movement of certain species (would need links to species abundance and distribution surveys); and,
   - Effects of EMF on fish.

   Observations with active sonar devices used for monitoring fish movements has suggested that marine mammals exhibit very strong negative responses to the sounds emitted (A. Redden, pers. comm. 2013). This might provide an effective means of deterrence, and needs to be evaluated further.

10. **Marine Bird Presence**. Marine birds are considered at only moderate or low risk from TISEC turbines that are mounted at depths greater than 20 m, but surface-supported or anchored devices that may lie nearer the surface may be a different matter. This may require evaluation for such proposals. The degree of risk to marine birds is difficult to assess in part because documentation and monitoring of marine birds have been very sporadic in the

Bay. Canadian Wildlife Service data on marine birds has primarily been obtained from ships of opportunity, which includes ferries, research vessels, and some regular commercial vessels, and thus is concentrated in limited areas or along specific routes (AECOM 2010). (Experience with the Annapolis Tidal Generating Station indicates that marine birds are not likely to encounter the turbine and are therefore not likely to be at risk in a tidal range development: on the contrary, observations indicate that some of the gull species quickly learn that the warning siren sounded before the turbine gates are opened at Annapolis causes them to congregate in the area of the downstream tailrace, where they are able to feed on young fish forced to rise to the surface by turbulence).

Recommendation: Shore- or vessel-based monitoring of marine bird activity in the potential TISEC sites along Digby Neck would be a valuable addition to knowledge about Bay of Fundy marine birds.

11. **Cumulative Effects.** Because no large scale commercial arrays have yet been deployed, no research has been conducted on the cumulative effects of large scale arrays. As pointed out in Section 8, "there have been no published studies or models investigating the actual or potential long-term and regional impacts on marine and coastal biodiversity or ecosystem processes due to existing or proposed…TISEC installations".

    Recommendation: As projects move to array deployments in the UK, Nova Scotia-based researchers and regulators should maintain contact with their UK counterparts to transfer knowledge and experience in modeling, measuring and assessing cumulative effects. As noted, effects of large energy extraction from tidal flows can be predicted through hydrodynamic modeling. Additional current flow measurements are required over the entire water column to improve these models. These data are usually gathered once specific sites are chosen for a project; the data should be made available to researchers. Once an array project is operational, the predictive ability and accuracy of the computer models can be verified by observations and measurements.

12. **Coastal and Marine Spatial Planning.** As noted in the 2008 SEA (Jacques Whitford 2008): *"Any energy extraction development in the Bay of Fundy needs to be in conformity with an established and comprehensive coastal zone management policy in each province… Where such a policy is lacking or incomplete, completion and implementation should be a high priority in order that a policy vacuum does not impede progress."*

    Recommendation: The Province should consider coastal zone planning to address certain recommendations made above and in 2008 (for 2008 recommendations please see Section 13, Recommendations 18-20, 25 and 26). Coastal zone planning or marine spatial planning will also help identify potential area use conflicts and may lead to strategies to mitigate the effects of overlapping interests.

11.2 Socio-Economic Data Gaps

Promoting and retaining socio-economic benefits on provincial and local scales can be encouraged by assessing the current workforce and evaluating how the workforce can be utilized and adapted to meet projected needs. Four workforce development issues have been identified for the MRE industry, summarized in Drake (2012):

1. Availability of professional skills, in particular for engineering and project management professionals;
2. Availability of general labor in communities where devices are deployed (quantity and skills mix);
3. Inter-industry interactions and movement of workers between industries; and,
4. Quality and duration of jobs and how they address income distribution within the community.

In order to address skills shortages in the marine renewable energy industry, a comprehensive review of the current skills base is required. To determine future requirements at national or regional levels, consultation with industry is needed, as well as realistic growth targets for the offshore renewable energy sector (Mott MacDonald 2011). A strategy should be developed to address skills shortages, and it should be supported by industry, public and private education providers and other stakeholders (Mott MacDonald 2011; NRCan 2011).

Additional socio-economic data gaps were highlighted in Howell and Drake (2012). These included the need for:

- A strategic plan to guide the development and deployment of TISEC devices that is consistent with the Marine Renewable Energy Technology Roadmap;
- Jurisdictional and regulatory clarity *(currently being addressed)*;
- Streamlining of the evaluation, permitting and decommissioning process *(currently being addressed)*; and,
- Clarity on how benefits to the community will be incorporated into development agreements *(addressed)*.

At a 2011 workshop to identify challenges and data gaps to the development of small scale tidal energy projects in Nova Scotia, the following socio-economic data gaps and recommendations were compiled (Stantec 2011a). Although some of these data gaps are currently being addressed through the Marine Renewable Energy Strategy and changes to legislation, others remain.

Gaps / Barriers

- The socio-economic effects of tidal power on local communities are not well understood *(currently being addressed)*;
- Regulatory requirements for small tidal power projects are not well established and understood *(currently being addressed)*;
- There is a shortage of funding for projects, technology development, and research facilities;
- Lack of young professionals needed to support the vision of small tidal power development in communities;
- There is a need for more collaboration with other jurisdictions (e.g., federal, international, Maine, New Brunswick, etc) *(currently being addressed)*; and,
- Significant barriers to project financing. Devices are not yet cost-effective and insurance costs are very high.

Short Term Recommendations (<18 months)

- Conduct a socio-economic impact analysis of tidal power which considers, among other things, competing resource users and economic effects on local communities;
- Conduct stakeholder consultation to improve awareness of tidal power opportunities for community participation as well as to improve appreciation of competing resources for the tidal/ocean resource (shipping lanes, whale watching, fishers, recreational groups) *(currently being addressed)*;
- Encourage community participation in COMFIT program through awareness/education programs *(currently being addressed)*;
- Invest in resources to support municipalities including technical training sessions, economic development resources (e.g., economic development officers), and communication capabilities (e.g., high speed internet) *(currently being addressed)*;
- Encourage business/economic researchers to work together and coordinate research similarly to what has been done by scientists studying biophysical issues of tidal power;
- Invest in the promotion and marketing of Nova Scotia tidal resources internationally to improve awareness, attract investment, and improve opportunities to export technology *(currently being addressed)*;
- Engage regulatory authorities to identify opportunities to improve regulatory framework and awareness of regulatory requirements *(currently being addressed)*; and,
- Develop a creative business model with economic incentives (e.g., feed in tariffs) and suggested compensation models to encourage community participation and acceptance *(currently being addressed)*.

Long Term Recommendations (>18 months)

- Improve access to financing opportunities for small/medium businesses. This is in part accomplished by proving tidal technologies and minimizing risk for investors;
- Export technology internationally;
- Invest in local infrastructure improvements (e.g., wharfs, boats, cranes) to support tidal development.
- Develop markets for energy during off peak hours;
- Job creation needs to be a priority to minimize “brain drain” from rural communities and maximize opportunities for skill-set utilization; and,
- Encourage collaborate with other jurisdictions, including international (e.g., Maine) to advance technology and awareness and lower costs.

PART B: Community Response Summary Report

12. Community Perceptions and Interests

12.1 Community Response to the SEA Update

SEA Update community forums were held in Windsor, Parrsboro, and Digby in September 2013, in addition to the presentation made to the Mi'kmaw Conservation Group in Truro described in Section 12.3. Forums were developed around a research poster session, display tables, and presentations where the SEA Update was introduced and key findings from the update shared. In total, approximately 70 people attended the three community forums. Stakeholders had the opportunity to share their views on the SEA Update process and to raise questions and concerns related to tidal energy development in the Bay of Fundy. The PowerPoint presentations given at the events are included in Appendix B. The sections below report the questions and comments raised during the community forums and the meeting with the Mi'kmaw Conservation Group but do not present project team responses. Instead, the comments are summarized in table format; under the table column "Addressed" the reader is referred to the sections in the SEA Background Study where a response to the question or concern is provided, or the subject is discussed.

Participation Support Fund

To supplement information collected during the course of the SEA, OERA established the Participation Support Fund (PSF) to assist community based groups and not-for-profit organizations in the Bay of Fundy region to get involved in the SEA Update. The purpose of the PSF was to provide funding to undertake small research initiatives and to make technical submissions to the SEA process. Although the PSF was widely advertised to bayside communities and Mi'kmaq organizations, no PSF applications were received during the course of the SEA.

The comments provided represent the opinions and beliefs of those present at the community forums and the meeting with the Mi'kmaw Conservation Group. In some instances the views are not based on the most recent information on MRE and related research, regulations, or community engagement activities. The summary tables provided point readers to sections in the SEA Background Study that provide, to date, the most recent information on the subject identified by community forum participants and the Mi'kmaw Conservation Group.

12.1.1 Key Themes: SEA Update

Key themes from the SEA Update community forums largely reflected questions, issues and concerns raised in the 2008 SEA (Table 7). Notable concerns in the SEA Update community forums included:

- The role of Nova Scotia Power in the future of tidal energy development;
- The impact that the Muskrat Falls hydro project and the Maritime Link will have on the future of tidal energy development in the Bay of Fundy;
- The timing of commercial tidal energy development; and,
- Economic development opportunities.

Table 7. Dominant Tidal Energy Discussion Themes in 2008 and 2013

2008 SEA Community Response Themes	2013 SEA Update Community Response Themes
Energy policy	✓
Tidal technology	✓
Ownership and investment	✓

2008 SEA Community Response Themes	2013 SEA Update Community Response Themes
Potential development scenarios	✓
End uses of tidal energy	✓
The grid	
Tidal energy management	✓
Baseline information	✓
Bio-physical effects	✓
Socio-economic effects	✓
Environmental effects on turbine	✓
The SEA process	

The following sections highlight the issues, concerns, and questions addressed at the 2013 SEA Update community forums.

Energy Policy (EP)

Similar to the 2008 SEA community forums, some participants expressed the need to address climate change through policies that support renewable energy development such as tidal energy. Discussion typically focussed on policy-related issues including the Nova Scotia *Renewable Electricity Plan* targets, the cost of energy, and the level of commitment from the Nova Scotia Government and Nova Scotia Power Incorporated (NSPI) in investing in tidal energy development.

Participants were interested in learning about how tidal energy will contribute to Nova Scotia's 2020 renewable energy target. Concern was also expressed that the Muskrat Falls and Maritime Link projects may impact the future of tidal energy development in Nova Scotia. Several forum participants raised concerns about the role of NSPI in the future of tidal energy development in Nova Scotia. Several people expressed the opinion that NSPI was too focussed on fossil fuel based energy production.

One forum participant noted their disappointment in NSPI, remarking that the company was focussed more on profits than investments in renewable energy like tidal energy. Several other participants expressed their belief that NSPI was focussed too much on fossil fuels and other 'low hanging fruit'. There was disappointment among some forum participants that NSPI was no longer actively pursuing tidal energy development. One forum participant expressed their concern about the cost of renewable energy development such as wind, tidal and solar power. Will it take a significant rise in fossil fuel prices to accelerate the development of renewable energy technologies such as tidal energy? This participant then asked if anyone had been exploring the hydrogen economy. There were several questions regarding the role of the Renewable Electricity Administrator (REA).

> The REA is responsible for administering the competitive bid process for a minimum of 300 GWh of renewable electricity to reach the 2015 renewable electricity target. The REA works with NSPI in developing standard Power Purchase Agreements for renewable electricity projects. Acting as a conduit between renewable electricity developers, NSPI and government, the REA addresses all information requests and ensures that all developers receive information from any questions that are posed by a potential stakeholder.

Comment #	Comment Summary (Energy Policy)	See Report Section #
EP-1	Tidal energy contribution to 2020 renewable energy target	2.11.2
EP-2	Effect of Muskrat Falls / Maritime Link on commitment to tidal energy	2.11.4
EP-3	NPSI apparent lack of engagement in tidal energy	3.4
EP-4	Cost of tidal energy relative other renewable energy types	3.6 & 4.1
EP-5	Role of the Renewable Electricity Administrator	2.3.2

Tidal Technology (TT)

There were several questions that explored how tidal energy might be stored in the future if grid connectivity or capacity is not available. Interest was also expressed in learning about the challenges European tidal technology developers are experiencing. One participant was particularly interested in small-scale tidal technologies and the potential for developing independent tidal energy systems for personal use.

Although there was awareness of tidal energy related technologies developed in Nova Scotia, one participant questioned why there were no local companies developing tidal turbines. Other participants questioned whether Nova Scotia can compete internationally in terms of developing tidal energy related technologies.

Questions were raised about Ocean Renewable Power Company's (ORPC) Cobscook Bay Tidal Energy Project. How successful is the ORPC project? Can the same type of technology be used in Nova Scotia?

SEA Update presenters discussed the Cobscook Bay Tidal Energy Project at length as well as on-going research in energy storage.

There was a brief discussion at one forum regarding how fast the turbines spin underwater. One participant expressed interest in understanding the RPM's (revolutions per minute) necessary to produce energy. This began a discussion on the potential risk to fish from the rotating elements of the different devices.

Comment #	Comment Summary (Tidal Technology)	See Report Section #
TT-1	Energy storage and other technology challenges	2.11.3
TT-2	Lack of Nova Scotia based tidal turbine developers	3.5; 3.6; 6.3
TT-3	Interest in recent TISEC deployment in Maine, USA	5.4.3
TT-4	Interest in TISEC operating parameters	4.3

Ownership and Investment (OI)

Forum participants raised several questions and concerns related to tidal energy development, community development, and community ownership.

- How can tidal energy support community development and local services?
- How can local communities access power from tidal energy development to support community development initiatives?
- Are there community investment opportunities related to tidal energy development?

Questions were raised about the use of tidal turbines for small coastal and rural inland communities, such as whether they would be useful to a broad range of communities throughout Nova Scotia or whether opportunity was confined to specific regions.

- Could Windsor and other communities benefit from becoming involved in smaller tidal initiatives?
- Was the tidal bore sufficient to create energy for nearby communities?

In addressing these questions, the COMFIT program was discussed and its role in supporting community-based small-scale tidal energy development.

Comment #	Comment Summary (Ownership and Investment)	See Report Section #
OI-1	Interest in community development and investment opportunities	3.6 & 3.7
OI-2	Interest in accessing energy from tidal power for community use	2.4.1

Potential Development Scenarios (DS)

Participants had questions about how tidal energy development will proceed. Will it occur like wind development, with only a few turbines at first and then move to tidal farms – like wind farms? There was considerable interest at the community forums in understanding how tidal arrays will be organized and what type of research is required in order to move toward tidal arrays. There was interest in understanding how many tidal turbines and/or sets of arrays could be located at the FORCE site and how much energy these arrays could produce.

In the SEA Update presentations, tidal arrays and their distribution at the FORCE site was discussed as well as the research required to understand their bio-physical impacts.

Questions about the COMFIT program were also raised. Participants were interested in knowing whether there were already tidal turbines in the water in the Brier Island and Digby areas under the COMFIT program. Participants were curious about the future of COMFIT and how it would, or would not be available to support in-stream tidal energy and other forms of community-based renewable energy development over the longer term?

Comment #	Comment Summary (Development Scenarios)	See Report Section #
DS-1	Interest in incremental development of in-stream tidal energy in the Bay of Fundy	1.1 & 2.8
DS-2	Interest in tidal array scenarios/turbine density at different places within the Bay	4.3 & 5.0
DS-3	Interest in the future of COMFIT program and proposed deployments in the Digby Area	5.4.2

End Uses of Tidal Energy (EU)

Similar to the 2008 SEA community forums, questions and concerns related to the export of energy were highlighted. Questions were raised about whether there were plans in place for the export of tidal energy (i.e., an energy export strategy). One participant stressed the importance of having plans in place to deal with eventual excess energy from tidal energy projects. Plans could include export strategies, and plans for lowering the cost of energy for Nova Scotia residents.

One participant highlighted the Nova Scotia *Marine Renewable Energy Strategy* where challenges were addressed related to exporting energy. This forum participant noted the importance of involved parties (e.g., NSPI, the Nova Scotia Government, and others) working collaboratively to address the challenges of exporting energy.

Comment #	Comment Summary (End Uses)	See Report Section #
EU-1	Resistance to the export of tidal energy until provincial needs are met	2.11
EU-2	Recommendation to develop an energy export strategy	13.0
EU-3	Concern with infrastructure challenges to exporting electricity to other provinces	2.11

Tidal Energy Management (EM)

Forum participants expressed considerable interest in the overall state of tidal energy development in the Bay of Fundy. Concern was expressed at the apparent slow pace of development at the FORCE site.

- When is a second turbine going to be deployed at the FORCE site?
- What is the timeline for testing tidal array deployment? What is the best guess for time to commercialization?
- Who is driving the testing of different technologies at FORCE?

Some forum participants questioned whether the FORCE site was the most suitable location to test tidal turbines given its strong currents and tides. Could the challenges of deploying tidal turbines at the FORCE site discourage developers and investors from testing their devices at this location? If more suitable test sites were available (e.g. European Marine Energy Centre) why would developers choose to deploy and test their devices at FORCE?

Several participants asked about the process for removing tidal turbines. One remarked:

What will happen once the turbines are installed and there is a negative effect on marine mammals and fish? What would be the next step? Exactly how difficult is it to remove the turbines?

It was also important to some participants that measures be put in place (if they have not already been implemented) to remove tidal turbines should unforeseen impacts occur.

Comment #	Comment Summary (Energy Management)	See Report Section #
EM-1	Concern with the apparent delay in TISEC deployment	5.5
EM-2	Interest in timelines to commercialization	5.5
EM-3	Concern with technical challenges in the high energy Minas Passage	5.5
EM-4	Recommendation for plan to remove turbines in light of unexpected impacts	13.0

Baseline Information (BI)

Forum participants were interested in the types of research undertaken and the extent to which baseline studies have included a variety of topics such as fish and marine mammal distribution, sedimentation, submerged ice, and the potential changes in tide levels from tidal energy development. How would this research be collectively used to develop monitoring tools and indicators to manage tidal turbine sites?

Some participants were particularly interested in knowing if any surprises were discovered in the course of collecting baseline research particularly for their communities. Interest was expressed in knowing the next phases of tidal energy related research; i.e., what will be the major research challenges in the near term?

Questions were also raised about the state of European baseline studies in regards to tidal energy development.

- Have Nova Scotia organizations including government, universities and developers formed partnerships with their European counterparts exploring tidal energy development?
- To what extent are we learning from the European experience in tidal energy development?
- To what extent are they learning from us?
- What have been the biggest challenges faced by European tidal energy developers?

Comment #	Comment Summary (Baseline Information)	See Report Section #
BI-1	Significant interest in recent research and future research on tidal energy subjects	6.1 & 6.2
BI-2	Interest expressed in European study results	14.0
BI-3	Interest expressed in partnerships, challenges and learning opportunities	2.8 & 3.3

Biophysical Effects (BE)

Most of the discussions at the SEA Update community forums involved addressing questions related to the biophysical effects of tidal energy development in the Bay of Fundy. Typical examples of the questions raised include:

- What might be the effect on tide levels once tidal arrays are deployed at the FORCE site?
- What is the impact on fish and marine mammals from tidal turbines?
- What is the impact of electromagnetic fields (EMF) on fish and marine mammals?

Of the research conducted on the potential impacts of tidal energy development to date, community forum participants wanted to know how much research was theoretical and how much is practically applicable to installed turbines? There was concern that theoretical research may not be sufficient to guide decisions regarding deployment of tidal turbines.

Participants were interested in learning about the process of removing tidal turbines should significant impacts be discovered following their deployment. It was suggested that specific plans be developed for their removal should this situation arise.
Several questions were raised about impacts to fish, the tides, silt accumulation, and erosion from the development of the Annapolis Tidal Station.

- Could the same impacts be expected in the Bay of Fundy from other tidal energy projects?
- Could lessons learned from the development of the Annapolis Tidal Station be applied to other tidal energy projects in Nova Scotia?

Forum participants were also interested in what has been learned from European studies related to biophysical impacts from tidal turbines. Would this knowledge help our understanding of the potential biophysical impacts of tidal energy development in the Bay of Fundy? It was important to some participants that lessons learned from other regions like Europe be reviewed carefully as we proceed with tidal energy development in Nova Scotia.

A participant expressed the importance of taking local knowledge into consideration when developing tidal energy in the Bay of Fundy. One participant involved in the fishery felt that some DFO information related to fishery locations was not accurate (i.e., SEA report Figures 30, 31 and 33). This individual also noted that the proposed location of tidal turbines in Minas Passage did not conflict with local fisheries. Another participant noted that in their 40 years of experience they had never witnessed or heard of adverse effects on marine life from electromagnetic fields (EMF). It was suggested that more discussions occur with people involved in the local fisheries to better understand localized impacts.

There was concern expressed by a few participants that impacts to the environment will not be taken into consideration at the level they would desire. One participant felt that in the end, economic development would trump environmental concerns, suggesting that turbines would remain in the water despite their negative environmental effects.

Comment #	Comment Summary (Biophysical Effects)	See Report Section #
BE-1	Subjects of interest: changes to tides, EMF, fish & mammal collision risk	6.2
BE-2	Concern that theoretical results may not apply to real life situation	6.1
BE-3	Interest expressed in lessons learned at the Annapolis Generating Station	4.2.1 & 7.1
BE-4	Question regarding the process for removing tidal turbines should significant negative impacts be discovered.	13.0
BE-5	Recommendation to use local knowledge	13.0
BE-6	Concern that economic interests may override environmental protection and conservation.	13.0

Socioeconomic Effects (SE)

Participants were most interested in understanding the range of socioeconomic benefits and strategies for maximizing the benefits associated with tidal energy development.

- How can communities such as Parrsboro and Digby maximize the potential benefits associated with tidal energy development?
- How might tidal energy development support niche businesses in rural communities?

One participant asked if a cost/benefit analysis had been conducted for tidal energy development in Nova Scotia.

There was also interest among some forum participants in knowing the level of visitation at the FORCE Visitor Centre. Did the Centre keep accurate records of visitation? How many visitors were from out of province? What was the local socioeconomic impact from visitors to the FORCE Visitor Centre?

Comment #	Comment Summary (Socioeconomic Effects)	See Report Section #
SE-1	Interest in pathways to maximizing community economic benefits	3.5 to 3.7
SE-2	Interest in whether a cost benefit analysis had been conducted for this industry	2.8
SE-3	Interest in use of and statistics at the FORCE Visitor Centre.	7.11.2

Environmental Effects on the Turbine (EE)

Community forum participants were very interested in learning more about the OpenHydro test (2009) at the FORCE site. Why did the OpenHydro turbine fail? What happened exactly? What did the tides do to the turbine? Forum participants wanted to know if the data sensors picked up any useful information during the testing of the Open Hydro turbine. How might lessons learned from the OpenHydro experience be applied to future deployment of tidal turbines and tidal arrays?

Comment #	Comment Summary (Environmental Effects on the Turbine)	See Report Section #
EE-1	Interest in learning more about the OpenHydro deployment	3.4
EE-2	Interest in lessons learned from OpenHydro deployment	3.4

12.2 Background Public Perceptions of Tidal Energy Development in the Bay of Fundy

In addition to the SEA Update community forums, there were other opportunities to learn about public perceptions of tidal energy development in the Bay of Fundy. Community and stakeholder discussion on tidal energy development has been undertaken recently during the development of the *Community and Business Tidal Energy Development Toolkit* (2013), the *Tidal Energy Community Engagement Handbook* (2013) and over the course of the *Southwest Nova Scotia Tidal Energy Resource Assessment* (2013). These consultation processes follow engagement undertaken prior to making amendments to electricity regulations, the environmental assessment undertaken for the FORCE site (2009-2010) and the Phase I Bay of Fundy SEA (2007-2008).

12.2.1 Community and Business Toolkit for Tidal Energy Development and Community Engagement Handbook: Stakeholder Meetings

Six stakeholder meetings were held in Fall 2012 and Spring 2013 in Brier Island, Long Island, Digby and Windsor to solicit feedback on early drafts of the *Community and Business Toolkit for Tidal Energy Development* and the *Community Engagement Handbook.* Stakeholders included village commissioners, residents, municipal and county councillors, and representatives from chambers of commerce and regional development authorities. While the purpose of these meetings was to focus specifically on how to improve the *Tidal Energy Toolkit* and the *Community Engagement Handbook* from stakeholder perspectives, discussions also included the role and value of tidal energy development in the Bay of Fundy.

Stakeholders in Digby and Brier Island were more knowledgeable about tidal energy development and were optimistic about its potential to provide social and economic benefits, specifically job creation. Concern was expressed about timelines in tidal energy development and it was expressed that the sooner development occurred the better. Misinformation about energy rates existed, as there was an underlying assumption that energy rates would drop quickly and significantly given the proximity of the resource. An underlying question emerged – *if tidal energy development is not a cheaper energy alternative for residents and businesses, why would we do this?*

Stakeholders in the West-Hants (Windsor meeting) area were less optimistic about the future of tidal energy development. *It'll never happen* was a common thread in the discussions. And similar to the meetings in Brier Island and Digby, there was lack of knowledge regarding the costs of residential and business energy following development of tidal energy projects.

Collectively, stakeholders indicated that should tidal energy development proceed, it should be done incrementally and with respect to sustainable economic and community development. Significant effort must be made to support the local supply-chain and the use of other local and regional assets.

12.2.2 Southwest Nova Scotia Tidal Energy Resource Assessment

The goal of this project was to assess in-stream tidal energy resource opportunities in southwest Nova Scotia defined as Shelburne, Yarmouth and Digby counties. Community engagement was included as one of several key project objectives. The objective of the community engagement meetings was to engage users of the marine environment, in particular the local municipal governments, fishers, tourism operators, and Mi'kmaq communities. The project incorporated aspects of the Mi'kmaq Ecological Knowledge Study (MEKS) conducted for this portion of Nova Scotia (MGC 2012).

Common themes and discussions emerging from stakeholder meetings included:

- The COMFIT program;
- Grid limitations;
- The role and opportunities for the municipality and local business;
- The turbine technologies involved;
- Sustainable and environmental development;
- Potential impact on the fishery and other existing users; and,
- Research and development activities completed, in process, and planned.

Most stakeholders viewed tidal energy development positively given its potential to stimulate economic development. The importance of this 'pioneering' work to advance tidal technologies and build capacity and expertise in the industry is seen as an important opportunity to develop and in so doing contribute to both the local and Nova Scotian economy.

12.3 Mi'kmaq Perspectives on the SEA Update: The Mi'kmaw Conservation Group

As part of the efforts to contact Mi'kmaq representatives and invite them to meetings or presentations, phone calls were made and emails sent to number of Mi'kmaq on numerous occasions beginning in June 2013. The people contacted during the course of this study include:

- Lisa Francis, Acadia First Nation;
- Todd Labrador, Acadia First Nation;
- Jeff Purdy, Acadia First Nation;
- Don Julien, Confederacy of Mainland Mi'kmaq;
- Dawn McEwan, Bear River First Nation;
- Eric Christmas, KMKNO;
- Melissa Nevin, KMKNO;
- Twila Gaudet, KMKNO;
- Louise Bernard, Union of Nova Scotia Indians;
- Randy Cochrane, Native Council of Nova Scotia;
- Cory Francis, Angie Gillis, Mi'kmaw Conservation Group;
- Barry Francis, Department of Energy; and,
- David Miller, Department of Energy Aboriginal Affairs Consultant.

After consultation with representatives from the Confederacy of Mainland Mi’kmaq, the Mi’kmaw Conservation Group (MCG) was recommended as the key Mi’kmaq organization to engage. The MCG is an organization within the Confederacy of Mainland Mi’kmaq. The MCG represents six communities including:

- Annapolis Valley First Nation;
- Fort Folly First Nation;
- Glooscap First Nation;
- Indian Brook First Nation;
- Millbrook First Nation; and,
- Pictou Landing First Nation.

The Bay of Fundy and its watershed are both culturally and spiritually significant to the Mi’kmaq and the MCG is charged with their protection through supporting research and education relevant to the region and the communities they represent. The MCG Advisory Committee invited the project team to give a presentation regarding the SEA Update on September 26, 2013.

The meeting was attended by 15 Advisory Committee members and MCG staff and lasted approximately two hours. Prior to the meeting, the MGC received an electronic copy of the draft SEA Technical Report for review. A PowerPoint presentation was given (Appendix C) to introduce the SEA and present highlights from recent scientific research activities in the Bay of Fundy. Following the presentation, a question and answer session was held, which led to discussions on a variety of subjects by members of the MCG. The sections below summarize the issues, concerns, and questions raised during the question and answer session.

Baseline Information

Concern was expressed that DFO lacked research on where fish were caught for commercial purposes within the Bay of Fundy. This was thought to limit the ability of scientists to predict potential turbine impacts to fish. It was also noted that international studies on impacts to fish and biological habitat from tidal energy projects were not definitive enough and could not necessarily be used to guide tidal energy development in the Bay of Fundy. Concern was raised over the lack of baseline data and that development might proceed based on studies and results from international research projects. It was expressed that tidal energy turbines should not be deployed without proper tests and solid baseline data.

MCG advisory committee members expressed the need to explicitly identify tidal energy project “showstoppers”. What levels of impact to fish and habitat are acceptable and what levels or types of impact would not be acceptable?

The point was also made by a committee member that water is a structured environment where fish and other organisms occupy different parts of the water column for different reasons at different times. How much is understood about the structure of the water in the passages proposed for tidal energy development (e.g., Minas Passage, Digby Gut, etc.)? How do fish use these passages? Passages are different and one cannot assume they are homogenous.

The two Mi’kmaq Ecological Studies (MEKS) described in Section 2.9 were discussed as projects that explored the cultural, spiritual and socioeconomic significance of the Bay of Fundy to the Mi’kmaq. The studies were perceived by this participant to provide valuable background information of historical and current resource use in and around the Bay of Fundy by the Mi’kmaw people. The MEKS studies resulted from a recommendation made in the 2008 SEA.

Biophysical Effects

Committee members expressed concern about potential impacts to eels from electromagnetic fields (EMF). There was also brief discussion regarding EMF impacts from the Canso Causeway on fish.

Questions were raised regarding international studies on impacts to fish – did they also include smaller fish? There was concern, for example, that herring and gaspereau, which are common in the Bay of Fundy, have not been studied elsewhere and so study results from international projects may not be applicable to common species in the Bay of Fundy. Because these smaller fish use the tides to support migration to their spawning grounds, there was concern that taking energy out of the system may impact their ability to migrate effectively. Concern was also expressed over the impacts to species such as Atlantic salmon. It was noted that as a result of past development, moose have disappeared on the mainland and other species are threatened. A committee member expressed concern that tidal energy development may similarly have negative effects. Will tidal energy turbines create more impacts and threaten more species?

MCG advisory committee members discussed the process for removing the turbines should significant impacts to fish and habitat occur. What level of impact is necessary to trigger turbine removal? There was serious concern that there was no process in place should such a situation arise.

Participants explained that when impacts occur (e.g. fish, habitat, etc.), indigenous people are impacted disproportionally given their unique and historical connection to the land, and their reliance on natural resources for cultural, spiritual and food harvesting purposes.

Engagement

An Elder on the MCG advisory committee indicated that engaging the Mi'kmaq community on issues related to tidal energy development was critical. The Elder noted that he believed the government has historically failed to engage the Mi'kmaw people adequately with respect to resource development projects. He expressed worry that he would not see proper engagement with the Mi'kmaw people in his lifetime, but did not elaborate on the preferred form of engagement. Other committee members expressed a general sense of frustration over lack of long-term engagement by government on issues related to resource development and resource extraction. It was also expressed that indigenous communities were yet to benefit from extraction of resources in the way that other communities have benefited.

Concern was expressed over the lack of trust in the government and government processes such as the SEA for tidal energy. Some of the MGC members felt that indigenous concerns do not appear to them to be a priority with government and research scientists.

MCG committee members indicated that community consultation and engagement needs to be a longer term, on-going process. The SEA and the SEA Update are technical reports and not everyone in the Mi'kmaq community can understand the material. There is a need to take time to properly educate Mi'kmaq people in order to develop a meaningful engagement process.

There was discussion on when and how the Mi'kmaq should be engaged in tidal energy development. A participant indicated that the government could have engaged the Mi'kmaq earlier in the SEA process.

Please note that prior to the award of the SEA contract, the Mi'kmaq were engaged by DOE at the Energy Consultation Table where KMNKO and the Assembly of Nova Scotia Mi'kmaq Chiefs were present. The Mi'kmaq were also engaged at the outset of the SEA process through membership on the Stakeholder Roundtable as well as Mi'kmaq-specific outreach conducted during the course of the SEA, as described above. In addition, two Mi'kmaq Ecological Knowledge Studies (MEKS) were conducted prior to tidal energy development in the Bay of Fundy. Mi'kmaq communities were also consulted during course of the 2013 Southwest Nova Scotia Tidal Energy Resource Assessment Project.

SEA Process

There was a brief discussion on the SEA process. Meeting participants suggested the SEA process appears to be a precautionary approach to tidal energy development and expressed the opinion that it seemed to be the correct way to proceed.

Other questions were raised about SEAs. Is this SEA Update related to the Cape Breton SEA? Was there an SEA and/or EA conducted on the Annapolis River prior to development of the Annapolis Tidal Station? Further discussion explored other opportunities for Mi'kmaq to contribute to the SEA Update. This included discussion of the Participation Support Fund to further support Mi'kmaq engagement in the tidal energy development discussion.

Socioeconomics

MCG advisory committee members discussed possible socioeconomic opportunities related to tidal energy development. Participants wondered if there were opportunities for investment in tidal energy development by Mi'kmaq communities and organizations and discussed the COMFIT program.

Comment #	Comment Summary	See Report Section #
MMP-1	Concern expressed with the completeness of background fish studies	6.1 & 6.2; 7.3
MMP-2	Concern expressed with the applicability of international studies to the Bay of Fundy	13.0
MMP-3	Recommended identification of "showstoppers" prior to deployment	13.0
MMP-4	Concern expressed regarding EMF effects on eels	6.2.5
MMP-5	General deep concern over potential impacts to a variety of species	7.0
MMP-6	Recommended establishment of a process to remove turbines in face of substantial negative impacts	13.0
MMP-7	Concern expressed regarding disproportionate effects to Mi'kmaq	13.0
MMP-8	Perceived lack of appropriate level of engagement on tidal projects and resource development	12.3
MMP-9	Interest in SEA process and connection to SEA undertaken in Cape Breton	Not addressed
MMP-10	Need to allocate time to explain certain technical subjects to interested people	13.0
MMP-11	Interest in development and investment opportunities for Mi'kmaq communities	13.0

12.4 Summary of Key Concerns 2013

Key issues and concerns related to tidal energy development were raised in the SEA Update community forums as well as in the meeting with the Mi'kmaq Conservation Group (MCG) Advisory Committee. Other community engagement processes prior to the SEA Update such as presentations given during *Community and Business Tidal*

Energy Development Toolkit (2013), the *Tidal Energy Community Engagement Handbook* (2013), and the *Southwest Nova Scotia Tidal Energy Resource Assessment* (2013) highlighted additional concerns related to tidal energy development in the Bay of Fundy.

Significant concern was expressed and clarity sought in the community forums and the MCG meeting regarding "showstoppers" for tidal energy development. What might these "showstoppers" include? It was clearly expressed that plans should be in place to remove turbines in the face of unexpected effects. These concerns have been carried forward as recommendations to this report (Table 8).

There was also concern that currently available background information regarding fish may not be sufficient to accurately gauge future impacts. Although considerable research on fish movement has been conducted since 2008, researchers noted that working turbines are required to fully assess any actual risk that may be posed.

Stakeholders were clearly interested in understanding socioeconomic development opportunities for their communities. Specifically, what types of economic benefits could be expected from tidal energy development? What types and number of local jobs could be expected from tidal energy development? Several economic development reports are cited in this SEA report (please see section 3.0) and OERA has recently initiated a research project aimed at assessing the value proposition of future tidal energy developments to Nova Scotia's marine technology industry. The results of this work are expected in 2014. As noted in section 3.6, recent studies have suggested deployment of just 55 tidal turbines with 2 MW ratings has the potential to create 340 person-years of employment, amounting to approximately $165 million. Service and maintenance over the life-span of the tidal turbines could add another 550 person-years and benefits in the order of $30 million.

While the 2008 SEA recommended an incremental approach to tidal energy, there was concern expressed in 2013 SEA Update as well as other recent tidal energy related engagement processes, that the pace of tidal energy development was too slow. On the positive side, this allows researches additional time to build background data sets and more fully characterize the marine environment before TISECs are deployed. The apparent slow development pace may result from economic constraints imposed by tighter venture capital markets since 2008, combined with the numerous technological challenges faced by this young industry.

13. Tidal Energy Industry Summary, Bay of Fundy

In Nova Scotia, tidal energy is expected to help reduce our dependency on imported fossil fuels and limit greenhouse gas and air pollutant emissions. Provincial legislation requires 40% of the electricity consumed in Nova Scotia to be generated from renewable sources by 2020. To achieve this target, an additional 1,800 GWh of renewable electricity will be required annually, post 2015. The economic benefits that can be realized by participating in this emerging industry, and the increased energy security that comes from using local renewable energy sources, are the basis for the Province's support of tidal energy in Nova Scotia.

Canada's *Marine Renewable Energy Technology Roadmap* estimates $2 billion in annual economic value to Canada by 2030 from investment in marine renewable energy development. It envisions 75 MW of marine renewable power installed by 2016, 250 MW by 2020, and 2,000 MW by 2030. In the Bay of Fundy, the Province's *Marine Renewable Energy Strategy* has established a target of 300 MW of commercial tidal development in the post-2020 period.

To put this in context, Nova Scotia consumes approximately 12,000 GWh of electricity per year. The Maritime Link will provide at least 895 GWh/yr to Nova Scotia and up to 1135 GWh to the province during the first 5 years of its operation (2017-2022). This represents approximately 61% of the new electricity (1800 GWh) needed to meet the 2020 renewable energy target. Post 2020, multiple in-stream tidal arrays totalling 300 MW and operating at 50% capacity could produce approximately 1300 GWh of electricity per year[12]. These calculations suggest that the 2020 target will be met by the Maritime Link together with additional new wind and tidal power, combined with other sources such as natural gas and biomass. As tidal energy becomes increasingly commercialized and the full 300 MW of tidal energy is deployed post 2020 (as proposed in the *Marine Renewable Energy Strategy*), the province will exceed its 2020 target and successfully transition from power generated largely from fossil fuels to power generated largely from renewable sources.

Internationally, there is increasing demand for sites that can host arrays of large scale turbines for commercial purposes. The FORCE site is designed to accommodate pre-commercial arrays consisting of multiple turbines that can transmit electricity to the grid to be distributed throughout the province. At the same time, smaller scale units suited to lower current speeds are proposed for three COMFIT approved sites in the Digby region. These units are intended to distribute electricity to local consumers, rather than transmit electricity on the provincial grid.

The current timeline for the development of this industry in Nova Scotia forecasts deployment of small scale single devices in the Digby area beginning in 2014, and large scale single devices at FORCE in 2015-2016. Tidal arrays are projected at FORCE by 2020 with commercially competitive in-stream tidal energy developing in the post-2020 period.

The Bay of Fundy is a complex, biologically rich system both in terms of species diversity and biological productivity. The Bay attracts migratory birds, fish and marine mammals from geographically distant areas and is intimately linked with these areas through a web of biological and physical connections. Through research conducted over many years in the Bay of Fundy, including recent studies funded to assess the effects of extracting tidal energy, these connections are increasingly better understood and the biophysical characteristics are better documented. This in turn allows more accurate predictions of the potential effects of tidal devices, and points to areas where further research can be focused.

To encourage and ensure the incremental industry development recommended in the 2008 SEA, a series of research projects and related steps have been undertaken in preparation for future tidal device deployment. Since 2008, researchers have greatly increased our knowledge of:

[12] 8760 hours per year x 50% x 300 MW = 1,314,000 MWh/yr or 1,314 GWh/yr.

- The energy available within Minas Passage and the passages hosting the COMFIT approved sites in the Digby area;
- The potential effects of energy removal on the tidal range, sedimentation and erosion patterns;
- The potential environmental interactions, especially with respect to fish and mammals;
- The technologies available for environmental monitoring of in-water devices; and,
- The challenges of device deployment and environmental monitoring of operating devices.

Since 2008, considerable research effort has been devoted to understanding the behavior of fish and marine mammals at the FORCE site and within the Minas Passage in general. Studies have included tagging selected species such as sturgeon, striped bass, and eels to better understand what portion(s) of the water column they occupy and how they migrate through Minas Passage. Different sonar techniques have been field tested to determine their effectiveness at monitoring fish movements. The presence and movement of porpoises and dolphins have been successfully studied using passive acoustic monitoring (PAM) devices that provide data on depth, direction and speed of species' movement.

Despite these advances, additional work is required to determine when and where the numerous resident and migratory fish species traverse Minas Passage. In addition, fish response to turbines has not been convincingly documented at other test sites or within the Bay of Fundy. At this time, it is not clear if fish can detect operational devices and avoid them, although evidence from other sites suggests the fish can and do avoid turbines. Finally, additional work must be undertaken to determine how fish-turbine interactions can be successfully observed and monitored in deep water, high energy environments. To this end, FORCE is currently designing a multi-instrument sensor platform that will be deployed on the sea floor with the turbines. The sensor platform will be equipped with acoustic (sonar) and optical (camera) instruments, and be cabled to shore, allowing for real time data collection and analysis.

To date, the lack of an operating turbine installed in the Bay has limited research efforts aimed at establishing the responses of fish and marine mammals to operating turbines. At this point, experience with installed, operating turbines is required to assess the actual risk to fish, marine mammals and sea birds.

Incremental development of tidal energy may result in economic benefits for the Nova Scotia marine technology industry, as well as for marine and manufacturing-related service sectors. At the same time, consideration must be given to potential negative economic effects so that these effects can be proactively managed and their impact minimized.

Commercial tidal energy arrays have the potential to displace other activities that generate economic return and provide livelihoods for bayside residents. These activities include a broad range of fisheries, recreational and tourism-related activities, marine transportation, and cultural/spiritual or sustenance uses by the Mi'kmaq of Nova Scotia. Secondary and tertiary effects of a burgeoning new industry may include the need for additional, unplanned investment in new infrastructure, competition for limited provincial investment resources between different communities, and increases to housing and living costs associated with the new industry. These economic consequences must also be considered as the industry transitions from single device demonstration to multi-device commercialization.

To a certain degree, questions, issues and concerns expressed during the course of this update reflect those reported in the 2008 SEA. However, three items of particular interest were raised on several occasions and are considered to represent present-day issues in the context of the SEA Update.

1. Both community residents and the Mi'kmaw Conservation Group (MCG) expressed concern over the lack of potential, clearly documented tidal energy "showstoppers" – that is, a definition or list of anticipated or

unanticipated environmental effects that would, individually or in combination, result in the removal of tidal energy turbines. The MCG suggests that the government and tidal developers together develop a plan that clearly expresses how, and under what conditions the turbines would be removed. These concerns have been formulated as a recommendation in Table 8 at the end of this chapter.

2. Both residents and the Mi'kmaw Conservation Group requested additional clarity regarding opportunities for future economic development resulting from this industry. Although both groups recognize the difficulty in defining specific economic benefits at this early stage, both felt that on-going opportunities to meet, discuss and participate as the industry developed would provide useful information to help them make informed decisions on the subject.

3. Community residents support the Province's incremental approach to tidal energy development and recognize the benefits from assessing potential impacts and benefits in a step-by-step fashion. Despite this, several residents in different forums commented on the apparent slow pace of development, compared to their expectations in 2008. It was generally understood by participants at the community engagement forums that the Bay of Fundy is a significantly more challenging working environment than perhaps was originally appreciated.

Tables 8 and 9 summarize the current key environmental and socio-economic issues associated with tidal energy development in the Bay of Fundy and provide recommendations or approaches to address these issues. The recommendations are classified as "Category A" to indicate priority over the near term (to five years from now) and "Category B" to indicate priority over the longer term. Table 10 presents recommendations made at the conclusion of the 2008 SEA that have been partially addressed or not addressed to date. As noted in section 2.10.1, the full list describing the current status of all 29 recommendations from 2008 is presented in Appendix A.

Table 8. Environmental Topics of Interest

Biophysical Topics	Observations & Recommendations
A. Tidal Lagoons. The ecological implications of tidal lagoon projects in Nova Scotia have not been extensively explored because at present there has been no formal registration of a well-defined project.	Observation: Additional specific and detailed information describing a Nova Scotia tidal range project would be needed so that targeted baseline and environmental effects research could be undertaken. Past studies of tidal range-based proposals and of existing tidal barriers (e.g. causeways) provide a wealth of basic knowledge that could be applied if a detailed, formal proposal for a tidal lagoon in Nova Scotia were to be made. Major environmental issues for consideration include: effects on hydrodynamics; effects on mammals, fish and fisheries; and sedimentation – both near-field and far-field.
B. Need for Operating TISECS. The major risks of in-stream and tidal range developments are associated with changes in hydrodynamics (flow velocity, turbulence etc.), electromagnetic effects, and the direct and indirect effects on marine fish, mammals, birds and turtles. Quantification of these risks is not yet possible because of the few deployments, limited monitoring, and technology-specific features of the tidal devices tested.	Observation: The adaptive management approach recognized by the NSDOE, DFO, and the US Federal Energy Regulatory Commission (FERC) is reportedly an effective method of managing the risks posed by these developments. Observation: Nova Scotia researchers are currently monitoring research on the environmental effects of TISEC devices deployed in other countries. Important knowledge can be gained from other jurisdictions, in particular through agreements with the United Kingdom. The lack of direct experience with extended TISEC deployments anywhere in the world, and the site-specific nature of environmental effects, underline the importance of continued evaluation of the impacts to marine resources (especially species at risk) and the value of information exchange with groups involved in TISEC research outside Canada.
C. Energy Extraction. The potential effects of energy extraction on physical processes (tidal currents, vertical mixing, sediment dynamics) constitute a key environmental issue. Empirical data on tides in the Bay of Fundy are extremely limited. Tidal data is important both for more accurate resource assessment and for modelling environmental effects. Larger soft-bodied forms such as jellyfish and comb-jellies might be particularly susceptible to the shear forces and turbulence associated with TISEC devices. If large scale energy extraction results in increases in tidal range – and hence tidal mixing – in the Outer Bay of Fundy, increased availability of deeper-dwelling pelagic species to mammal, fish and bird predators could be a	4. **Recommendation C1 (Category A):** The Province and academic institutions should continue to fund and undertake research into resource assessments and hydrodynamic and sediment modeling to further refine our understanding of the effects of energy extraction. Observation: Past research and modeling indicates that an increase in vertical mixing in the Outer Bay may result in increased biological productivity, with possible positive effects on, for example, some fisheries. 5. **Recommendation C2 (Category B):** Far field effects monitoring by proponents and researchers of larger (e.g. FIT) installations must include consideration of the critical ecological role played by soft-bodied forms such as jellyfish and comb-jellies.

Biophysical Topics	Observations & Recommendations
significant outcome.	6. **<u>Recommendation C3 (Category A):</u>** The Province should consider funding the collection of long term tidal data at the future COMFIT tidal energy sites along Digby Neck similar to those data collected at the FORCE site.
D. Turbulence. The turbulence regime is a major uncertainty at all potential TISEC sites.	2. **<u>Recommendation D1 (Category B):</u>** Academic research on the subject of turbulence should continue so that potential far field and cumulative effects can be more accurately modeled as more and more turbines are deployed.
E. Fisheries. Because of widespread fishing throughout the Bay, the importance of fisheries to regional and local economies, and the fact that a number of species migrate into the Bay from many parts of the Atlantic Ocean, fisheries are an important consideration for sustainable marine energy development. Any assessment of risk to fisheries undertaken for specific projects will need to take into consideration the varied fishing activities found in different portions of the Bay. Management decisions have to be made recognizing the potential implications for a wide range of interested parties: those directly involved in fisheries and aquaculture operations, those who depend upon the same infrastructure resources, and their communities of interest.	3. **<u>Recommendation E1 (Category A):</u>** In order to reach valid conclusions regarding the species and habitat types in areas of future tidal energy interest, additional academic research focused on those aspects of fish and fish habitat most likely to be disrupted by both FIT and COMFIT projects is required. This work should be tailored to the environments and species of this region, including species at risk and evolve over the longer terms as arrays are deployed. A joint strategy developed by the Province and academic researchers should be considered to fund and acquire this information. 4. **<u>Recommendation E2 (Category A):</u>** More detailed, site-specific information regarding catches (location, tonnage, season, etc.) would be extremely useful to help determine the magnitude of impacts from displacement and exclusion so these impacts can be mitigated and potentially compensated. The Province in discussions with fishers' associations, DFO and other groups should develop and implement an information sharing system that will allow an accurate understanding of fishing pressure at potential FIT and COMFIT tidal energy sites.
F. Fish Behaviour. International studies on impacts to fish and biological habitat from tidal energy projects are not definitive and cannot necessarily be used to guide tidal energy development in the Bay of Fundy At all sites being considered for TISEC development, it is critical to obtain more detailed information about exactly where and when different species occupy or transit through the site. The limited international studies in which fish movements near TISECs have been monitored have not yet provided evidence of mortality, but equally, have not provided evidence that fish can avoid entrainment in the devices. Technology limitations are partly responsible for this.	3. **<u>Recommendation F1 (Category A):</u>** Academic and proponent-funded research needs to continue in Nova Scotia to assess the real risk of TISEC to fish species. The tagging program currently under way in Minas Passage (please see section 5.2.7) should be continued to provide more complete information regarding striped bass, Atlantic sturgeon, and American eel. Research regarding fish behavior near TISECs should be extended to COMFIT sites. Because of the limited capacity of academic institutions to obtain external funding for such research, government and private sector initiatives are required to facilitate and fund these research activities. 4. **<u>Recommendation F2 (Category B):</u>** Any development of a tidal lagoon will require the proponent to evaluate the extent of fish use of the proposed development site, which currently is entirely lacking.
G. Fish Habitat. Fish habitat is inadequately characterized in the proposed TISEC sites along Digby Neck.	2. **<u>Recommendation G1 (Category A):</u>** An assessment of fish habitat type and productivity should be undertaken by the proponent prior to TISEC

Biophysical Topics	Observations & Recommendations
	deployment at COMFIT sites.
H. Marine Benthos. The marine benthos is inadequately known in the Outer Bay.	2. **<u>Recommendation H1 (Category B):</u>** Video and/or diver observations should be incorporated in future studies undertaken by COMFIT proponents. Bathymetric surveys of the areas adjacent to future TISEC deployment sites are recommended.
I. Marine Mammals. For both tidal stream and tidal range technologies, environmental issues impacting marine mammals relate to direct effects, such as mortality associated with contact, and indirect effects, such as mortality effects on prey, changes in food concentrations as a result of changes in upwelling, and disturbance effects of construction and operation. Because of the novelty of TISEC devices, there is little information available to assess these implications. Studies in Strangford Lough (Northern Ireland) have shown that the local marine mammals avoid involvement with the MCT turbine. However, regulations require the device to be shut down if mammals approach too closely, so it is not clear that the mammals would never become involved with an active turbine. Differences between device design and operation, and site conditions limit the transferability of results from the limited monitoring of mammals at TISEC sites so far conducted. Some of the TISEC deployment strategies that have been proposed involve tethering to one or more anchor points by cables that may be essentially undetectable to marine mammals.	<u>Observation:</u> Marine mammal behavioral responses to TISEC devices in the Bay of Fundy cannot be determined until TISEC technologies are deployed. Because the Strangford Lough study was not aimed at studying behavior, it is not really feasible to infer from that study that mammals will always be able to avoid any TISEC design. Consequently, careful monitoring of mammal presence and behavior is essential for any TISEC deployment. 2. **<u>Recommendation I1 (Category B):</u>** Proponent funded observer-based monitoring should be employed at FIT and COMFIT sites until more automated technologies are available that will also give information on marine mammal movements when the animals are submersed, and hopefully provide information on the behavioral responses of mammals to the presence of operating devices. The Province through OERA should continue to fund the use of C-POD and icListen hydrophones to monitor porpoises and dolphins. If possible, mammal monitoring be expanded to areas of tidal energy interest that are not currently being monitored. <u>Observation:</u> Considerable additional study is required to assess whether technologies that are tethered by anchor cables (if such technologies are proposed in the Bay of Fundy) can be avoided by marine mammals. Exploration of potential options for deterrence should be undertaken before such turbines are installed.
J. Marine Birds. The risks posed to marine birds vary based on their ecology, the characteristics of the tidal power development, and the site location. Noise and vibrations associated with construction activities will act as a deterrent to all species of birds.	<u>Observation</u>: Shore- or vessel-based monitoring of marine bird activity in the potential TISEC sites along Digby Neck would be a valuable addition to knowledge about Bay of Fundy marine birds.
K. Area Use Conflicts. Surface-penetrating or floating structures could represent a permanent restriction for vessel activity. For safety, site preparation and construction phases will require exclusion of all other vessels (fishing, recreational and commercial) from a zone surrounding the site that is large enough to ensure minimum risk to vessels and operators. During TISEC operation, fishing activities may have to be curtailed in an area	<u>Observation</u>: Marine energy projects will need to be carefully evaluated for their impact on fishing, tourism and recreational activities. Some disruptive activities, such as those during construction (etc.) might be carried out at times when their impact on fishing, tourism and recreation would be much less. <u>Observation</u>: Negotiations regarding temporary and permanent access limitations must be held between project proponents and other area users. Project proponents should anticipate early and on-going consultation

Biophysical Topics	Observations & Recommendations
sufficient to ensure safety of fishers and to minimize the potential for fishing gear (etc.) to foul the turbine(s). Where a lagoon is to be constructed, the headpond area behind the lagoon wall is expected to be removed from access by other commercial and fishing vessels Construction and site preparation for both TISEC and lagoon developments will have similar effects on marine-based tourism activities as on fishing and transportation activities.	throughout the project preparation phase so that conflicting interests can be identified and competing claims resolved prior to deployment. Observation: MRE projects within or in close proximity to ecologically or culturally significant sites must be evaluated on a case by case basis. 2. **Recommendation K1 (Category B):** The Province needs to implement coastal zone planning techniques to address on-going area use concerns and to address the 2008 SEA recommendations (Recommendations 18-20, 25 and 26). Coastal zone planning or marine spatial planning will help identify potential area use conflicts and may lead to strategies to mitigate the effects of overlapping interests.
L. Noise and EMF. Limited knowledge exists of the effects of noise and EMF from the installation and operation of devices/arrays on marine mammals and fish including increased risk of barrier effects, habitat exclusion and species displacement.	2. **Recommendation L1 (Category A):** Proponent funded monitoring and in some cases modeling at both FIT and COMFIT sites should be used to determine: • Ambient (background) noise levels prior to deployment; • Noise levels generated from operational tidal devices; • Effects of noise on sensitive receptors such as marine mammals and fish; • Whether noise levels are causing barriers to movement for certain species along migratory routes and transit pathways; and, • Whether noise from devices is leading to habitat exclusion or species displacement. Observation: Data can be collected from monitoring/research programs of offshore wind developments (UK and Europe) to establish: • Noise levels generated during pile driving; • Effectiveness of mitigation measures to reduce noise levels; • Effect of noise from piling on sensitive receptors (e.g. marine mammals and fish); • Whether noise from piling activities associated with large wind farms is creating barriers to movement of certain species (would need links to species abundance and distribution surveys); and, • Effects of EMF on fish.
M. Cumulative Effects. There have yet to be any published models or practical research on the cumulative and synergistic impacts of large-scale TISEC arrays in conjunction with other nearby offshore industries. No TISEC projects have been installed in close proximity to one another, although the FORCE site may eventually provide some data on multiple technology installations. The presence of a single device is unlikely to have a significant effect on the	2. **Recommendation M1 (Category B):** The ultimate effects of energy extraction can be predicted through hydrodynamic modeling. To improve the accuracy of these models, the Province should consider funding additional and detailed current flow measurements over the entire water column. These data are usually not gathered until specific sites are chosen for a project. The predictive ability and accuracy of the computer models will then need to be verified by observations and measurements made once a project

Biophysical Topics	Observations & Recommendations
environment, but the cumulative interaction of industrial farms or arrays may significantly impact an area.	is operational. Observation: As projects move to array deployments in the UK, Nova Scotia-based researchers and regulators should maintain contact with their UK counterparts to transfer knowledge and experience in modeling, measuring and assessing cumulative effects.

Table 9. Socio-Economic Topics of Interest

Socio-Economic Topics	Recommendation / Observation
N. Heritage Resources. Installation and maintenance of land-based infrastructure, harbour or wharf expansion, infilling, etc. could potentially destroy concealed heritage sites or artifacts. Installation and operation of submarine TISECs and cables could similarly affect submerged heritage resources, including shipwrecks.	Observation: In the absence of existing information on near-shore locations of the Bay of Fundy, surveys using bathymetric and LiDAR survey techniques should be used by the proponent to investigate sites that are considered for tidal power development.
O. Project Red Lines. At this time what would constitute an "unacceptable" level of impact to critical biophysical processes and organisms that would justify cancellation or modification of a tidal energy project for any given site or project is unclear because of significant site and technology variations.	2. **Recommendation O1 (Category A):** The Province, in consultation with regulators, developers, researchers, the Mi'kmaq and other interested parties should convene an experts' workshop whose purpose would be to try and define or quantify what levels of impact by TISEC development would be unacceptable. The participants would for example compile an inventory of the various receptors and the level or degree of impact that could result in the adaptation of TISEC projects, removal of installed TISECs or halt the deployment of further TISECs at both FIT and COMFIT sites.
P. Mi'kmaq Concerns. There is potential for disproportionate impact to Mi'kmaq communities due to their reliance on natural resources for cultural, spiritual and food harvesting purposes. There is a perceived lack of long-term engagement with the Mi'kmaq by government on issues related to resource development and resource extraction. Community members indicated that community consultation and engagement needs to be a longer term, on-going process. Because of the technical complexity of reports (such as the SEA), understanding of issues by Mi'kmaq and the general public may be limited. There is a need to take time to assist Mi'kmaw people by developing a meaningful engagement process.	Observation: Project developers and regulators should consider the potential for disproportionate impact when assessing project specific and cumulative environmental effects of tidal energy projects. 3. **Recommendation P1 (Category B):** I n advance of new tidal energy projects or significant changes to existing projects, the Province should lead a dedicated Mi'kmaq engagement process. 4. **Recommendation P2 (Category A):** To the extent practical, governments tasked with engaging Mi'kmaq communities should work with the Mi'kmaq, including KMK and the Unama'ki Institute of Natural Resources to assist the development of more effective information and education programs targeted for the needs of Mi'kmaw people.

Socio-Economic Topics	Recommendation / Observation
Q. Economic Growth and Investment. There is widespread interest from Mi'kmaq and Bay of Fundy communities in learning about opportunities for investment in and economic growth from tidal energy development	Observation: Several initiatives have been completed or are underway (e.g., Drake 2012; Howell and Drake 2012; ATEI 2013; the Tidal Value Proposition Project) that can assist interested communities to determine how best they can benefit from tidal energy development. Observation: There is an opportunity to recruit Mi'kmaq people, fishers and other local residents to participate both in monitoring activities and research.
R. Energy Export Strategy. There is among some people an enduring interest in developing an energy export strategy that will outline how Nova Scotia energy consumers could benefit from the export of tidal energy from the province.	2. **Recommendation R1 (Category B)**: Energy export may occur at some point in the future following the development of large scale turbine arrays or tidal lagoon(s). In the future, the Province should consider developing an energy export strategy to assess and describe how Nova Scotians may benefit from the export of tidal-derived electricity from the province.
S. Infrastructure Upgrades. At present, an inherent limitation exists to the development of tidal energy in some locations because of inadequate infrastructure (e.g. transmission lines). This would eliminate some tidal power options unless the cost of upgrading infrastructure could be shared with other developments. There are likely to be cost implications to the actions taken to integrate tidal power into the grid.	Observation: If public funds are used to develop tidal energy projects, the Province should undertake additional analysis at COMFIT sites to understand infrastructure costs, system stability and interconnection options to neighboring regions. If private funds are used to develop these projects, then infrastructure costs would be borne by the proponent.

Table 10. Outstanding Recommendations from the 2008 SEA for the Bay of Fundy

Topic	Recommendation / Observation
Outstanding Recommendations from the 2008 SEA (please see Appendix A for all 29 recommendations from 2008)	
Recommendation 6: Provincial Standard for Ecological Data The Province of Nova Scotia require all marine renewable energy proponents and their consultants to ensure that ecological data is geo-referenced and metadata compiled in accordance with the relevant provincial standard.	PARTIALLY ADDRESSED AND ON-GOING. No provincial data standards have been issued to date. A provincial government strategy is currently being developed for all spatial data, including data for renewable energy projects. FORCE berth holders are required to share non-proprietary information related to their projects with the public. FERN is consolidating a searchable information database regarding tidal energy in Minas Passage. This recommendation remains valid.
Recommendation 18: Fisheries Database The Province of Nova Scotia (a) assist DFO to develop and maintain a geo-referenced database of fisheries resources and activities to be used to determine where tidal energy development would have least impact on the fishery and other marine resource uses, and (b) develop a detailed study of potential tidal energy exclusion zone requirements by type of activity (including different types of gear use), potential impacts and possible mitigative strategies.	PARTIALLY ADDRESSED AND ON-GOING. Through OERA's Participation Support Fund in 2008, the Scotia Fundy Mobile Gear Fishermen's Association conducted a database search to document the fleet's activities and catches in the Bay, and carried out in-depth interviews with fishers to collect relevant traditional knowledge. DFO and NSE are working together on a Statement of Best Practices. DFO is currently reprocessing fish landing data to generate maps that will help show where different species are caught within the Bay. This recommendation remains valid.
Recommendation 19: Compensation and Liability The Province of Nova Scotia facilitate the development of a preliminary mitigation process to address compensation for fisheries displacement, damage to gear, and other environmental impacts, and limits to liability before any demonstration project proceeds.	PARTIALLY ADDRESSED. Although no formal mitigation/compensation process has been established by the Province, FORCE carries liability insurance which extends to all berth holders. In addition, environmental impacts are monitored (to the extent possible) on an on-going basis, and all berth holders are required to table decommissioning and restoration plans intended to return their sites to a natural state as possible. This recommendation remains valid.
Recommendation 21: Fisheries Consultation and Involvement Protocol The Province of Nova Scotia work with marine renewable energy proponents, local fishers and other fisheries interests to develop procedures and protocols to ensure that fishers and fisheries stakeholders are informed and consulted at every stage of tidal development, both by the Province and by proponents.	PARTIALLY ADDRESSED AND ONGOING. Although no formal procedures or protocols have been developed, the Province through OERA has participated in the engagement component of the updated SEA and other past tidal-related initiatives. FORCE has continued to include local fishers and Mi'kmaq representatives on EMAC, and supported a collaborative project between local weir fishers and researchers at Acadia University. This recommendation remains valid.
Recommendation 25: Integrated Coastal Zone Management The Province of Nova Scotia develop an Integrated Coastal Zone Management (ICZM) Policy for the Bay of Fundy before large scale commercial marine renewable energy developments are allowed to proceed.	NOT ADDRESSED. The Province currently uses the Coastal Management Framework to manage coastal areas and issued a Draft Coastal Strategy for public comment in 2011. Public comments were summarized and presented to the Province in 2012. Should commercial arrays be proposed, more focused ICZM planning may help to minimize overlapping claims and

Topic	Recommendation / Observation
	mitigate conflict. This recommendation remains valid.
Recommendation 26: Geo-Referenced Tools to Indicate Opportunities and Constraints Nova Scotia, New Brunswick and Canada collaborate to prepare and maintain geo-referenced tools to indicate opportunities and constraints for the full range of marine renewable energy technologies, to support the allocation of marine renewable resources within the context of an Integrated Coastal Zone Management Policy.	NOT ADDRESSED. This recommendation remains valid although New Brunswick has chosen not to development marine renewable energy in the Bay of Fundy at this time.
Recommendation 28: Public Education and Awareness The Province of Nova Scotia work with marine renewable energy proponents, research institutions and environmental and community organizations involved in sustainability education, to develop a strategy for public education and awareness about marine renewable energy technologies.	PARTIALLY ADDRESSED AND ONGONG. Since 2008 the Province has collaborated with research groups and industry to promote tidal energy development and have liaised (through OERA) with communities during the engagement process for the SEA update. No formal public education strategy has been developed. NSE frequently presents information at educational institutions (schools, community colleges and universities) and other events. The Tidal Energy Toolkit (AETI 2013) provides additional information. This recommendation remains valid.
Recommendation 29: Long-term Integrated Management in the Bay The Province of Nova Scotia, partnering with New Brunswick, Canada, and the Gulf of Maine Council, study ICZM requirements, approaches and experiences, to provide the background for a major workshop to be held in 2009 to examine integrated management issues and organizational options for the Bay of Fundy.	NOT ADDRESSED. No specific ICZM workshop focused on the Bay of Fundy has been organized since 2008. This recommendation remains valid.

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Appendix A

Status of the 2008 SEA Recommendations

Status of the 2008 SEA Recommendations

The 2008 Phase I SEA of the Bay of Fundy concluded with a series of recommendations to guide the development of tidal energy in Nova Scotia, with a specific focus on the Bay of Fundy. This table reviews those recommendations and comments on their current status, validity and applicability. Recommendations that have not been fully addressed are also reported in the Executive Summary and in Section 13 of the main report.

Sustainability Principles and Overall Recommendations		
Recommendation 1	Sustainability Principles	The Province of Nova Scotia adopt ten specific sustainability principles to guide marine renewable energy development in the Bay of Fundy. **ADDRESSED. With minor changes to wording these ten sustainability principles remain valid. For reference, they are reproduced in Appendix A.**
Recommendation 2	Allowing the Demonstration of TISEC Technologies	The Province of Nova Scotia give the necessary approvals, contingent on satisfactory completion of a project-specific environmental assessment, to allow demonstration of a range of TISEC technologies in the Bay of Fundy. **ADDRESSED AND ON-GOING. The Environmental Assessment for the FORCE Fundy Tidal Energy Demonstration Project in Minas Passage was completed in 2009. Through the COMFIT program, FTI has been approved for three tidal energy projects in the Bay of Fundy to enable the demonstration of technologies as a part of an incubation centre in the Digby area; however these projects will not require environmental assessment as the nameplate capacity is less than 2MW.**
Recommendation 3	Marine Renewable Energy Legislation	Before large-scale commercial development proceeds, the Province of Nova Scotia enact legislation respecting the renewable energy resources in the Bay of Fundy. **ADDRESSED AND ON-GOING. The applicable legislation (*Renewable Electricity Regulations* amended in 2010) has been modified since 2008 following a consultation process; additional changes to regulations are expected. In the short-term, the *Regulations* will be amended to include the developmental FIT rates for tidal energy established by the UARB. NSDOE's public consultation for rate setting is ongoing and the UARB is expected to set the rate(s) for these projects in late 2013. It is also expected that in the near future, changes will be made to the *Regulations* to develop an approval and administrative process for the FIT program. This second set of amendments is planned to go for consultation in late 2013.**

Information Gaps and Research Requirements		
Recommendation 4	Research Program	The Province of Nova Scotia facilitate the development of a collaborative research program for marine renewable energy development in the Bay of Fundy. The design of the research program should include all levels of government, Aboriginal peoples, research institutions, and stakeholders. **ADDRESSED. OERA is mandated and funded by the provincial government to coordinate research respecting offshore energy including the subject of tidal energy.**
Recommendation 5	Mi'kmaq Ecological Knowledge Study	The Province of Nova Scotia ensure that a MEKS is carried out before marine renewable energy projects proceed in the Bay of Fundy, either as part of the research program identified in Recommendation 4 or as a requirement for project-specific environmental assessment. **ADDRESSED. A MEKS was completed following the 2008 SEA as part of the FORCE project approval. A second MEKS was completed in 2012 for the COMFIT projects in the Digby area, although the study area was expanded to include a much broader area.**
Recommendation 6	Provincial Standard for Ecological Data	The Province of Nova Scotia require all marine renewable energy proponents and their consultants to ensure that ecological data is geo-referenced and metadata compiled in accordance with the relevant provincial standard. PARTIALLY ADDRESSED. **No provincial data standards have been issued to date. A provincial government strategy is currently being developed for all spatial data, including data for renewable energy projects. FORCE berth holders are required to share non-proprietary information related to their projects with the public. FERN is consolidating a searchable information database regarding tidal energy in Minas Passage. This recommendation remains valid.**
Recommendation 7	Bay of Fundy Socioeconomic Background Study	The Province of Nova Scotia undertake a socioeconomic background study, as soon as possible to describe fully the communities, economies and cultures of the Bay of Fundy region and Mi'kmaq communities with fishing interests in the Bay. **ADDRESSED. OERA commissioned the current Background Report update, which builds on a recent OERA funded study entitled: Scoping Study on Socio-Economic Impacts of Tidal Energy Development in Nova Scotia: A Research Synthesis & Priorities for Future Action (Howell and Drake 2012).**

Implementing an Incremental Approach		
Recommendation 8	Marine Renewable Energy Demonstration Program	The Province of Nova Scotia establish a Marine Renewable Energy Demonstration Program (with a Stakeholder Advisory Board) to (a) encourage the development of a range of tidal energy and other marine renewable technologies (b) gather knowledge about environmental and socioeconomic impacts and benefits, and (c) initiate longer term research needed to predict cumulative and far-field effects in the commercial phase. **ADDRESSED. OERA in collaboration with Marine Renewables Canada (MRC) appears to be meeting the requirements described above. No Stakeholder Advisory Board has been established although FORCE has an active Community Liaison Committee (CLC) and Environmental Monitoring Advisory Committee (EMAC). FTI has also established a community liaison group in the Digby area. A Tidal Energy Stakeholder Forum is proposed in the *Marine Renewable Energy Strategy* (2012).**
Recommendation 9	Siting Demonstration Projects	The Province require proponents to consult with local fishers, other marine resource users including marine transportation stakeholders, and adjacent communities in the selection of sites for demonstration projects and to avoid or compensate the displacement of productive fishing activity. **ADDRESSED. This recommendation remains valid. Apart from the FORCE project, no recent project has required provincial participation. Proponents are legally required to consult with the stakeholders described above during the Environmental Assessment process.**
Recommendation 10	Environmental Assessment of the Demonstration Facility	The Province of Nova Scotia amend the provincial Environmental Assessment Regulations to designate tidal energy projects that produce 2 MW or more of energy as Class I undertakings. **ADDRESSED. The Environmental Assessment Regulations currently designate as Class I any project with a production rating of at least 2 MW derived from wind, tides or waves.**
Recommendation 11	Fundy Tidal Energy Research Committee	The Province of Nova Scotia initiate the formation of a federal-provincial Fundy Tidal Energy Research Committee, also involving the Province of New Brunswick, to determine baseline research requirements and to develop research and monitoring requirements for demonstration and future commercial projects. **ADDRESSED AND ON-GOING. The Province, through OERA, is represented on OERA's Research Advisory Committee. OERA continues to identify research needs and provide research funding to address issues related to MRE projects. Other research networks include FERN.**
Recommendation 12	Commercial Development Framework	The Province of Nova Scotia work with New Brunswick and the Government of Canada to develop a commercial development framework (guided by sustainability principles) for marine renewable energy, either through an expansion of the existing SEA process, or through a new process that includes stakeholder involvement. **ADDRESSED. The Marine Renewable Energy Strategy presents a commercial development framework for tidal energy. At this time New Brunswick has chosen not to pursue the development of tidal energy.**

Implementing an Incremental Approach		
Recommendation 13	Incremental Development and Removability	Larger commercial developments be required to develop incrementally in stages with an appropriate effects monitoring program; that all installations be designed in such a way that the machines, their footings and all cables can be completely removed if necessary and the site remediated to close to its former condition. **ADDRESSED AND ON-GOING. The Province and FORCE continue to express a desire to adopt an incremental approach to tidal energy development and employ adaptive management techniques to establish environmental effects.**

Integration of Marine Renewables and End Uses		
Recommendation 14	Nova Scotia Energy Priorities	The Province of Nova Scotia takes steps to maximize the benefits of commercial marine renewable energy projects to Nova Scotia. The Province's first priorities should be to (a) satisfy provincial, national and international greenhouse gas reduction commitments and (b) improve provincial energy security. **ADDRESSED AND ON-GOING. The Province has taken several steps to reduce GHGs and improve energy security. These steps include tabling the Renewable Electricity Regulations, introducing the COMFIT and FIT programs and issuing the *Marine Renewable Energy Strategy*.**
Recommendation 15	Conservation, Efficiency and Carbon Credits	*Nova Scotia Renewable Energy Strategy* and *Climate Change Action Plan* (a) place high priority on conservation and efficiency measures, and (b) implement a carbon credit trading scheme, or comparable measures, to strengthen the economic viability of the tidal energy industry. **ADDRESSED. The Province and NSPI are prioritizing energy conservation and efficiency. The Province is working on multiple fronts to achieve and retain economic benefits associated with the tidal energy industry. No carbon trading scheme has been implemented since carbon credits are not seen as the most effective way to strengthen the economic viability of the tidal energy industry. This recommendation dates to 2008; there is no *Renewable Energy Strategy* as such – the Province has implemented an *Energy Strategy* (2009), a *Renewable Electricity Strategy* (2010) and a *Marine Renewable Energy Strategy* (2012).**
Recommendation 16	Grid Capacity	The Province of Nova Scotia study (a) the advantages and disadvantages of developing more decentralized generation, (b) the current capacity of the grid to support additional renewable energy developments, and (c) required upgrades and how these should be financed. **ADDRESSED AND ON-GOING. To meet this recommendation, the Province commissioned the Wind Integration Study (Hatch 2008) to understand how to integrate intermittent renewable energy projects into the existing grid. It appears the currently legislated renewable energy targets can be met, but the required transmission upgrades and operational demands may increases costs. In 2012 NSPI commissioned a study of possibilities for the integration of renewable energy into the provincial grid, building on the 2008 Wind Integration Study. The study identifies operational and planning challenges associated with its integration (NSPI 2013). This recommendation remains valid.**
Recommendation 17	End Uses	The Province of Nova Scotia study alternate uses of marine renewable power generation to maximize benefits. **ADDRESSED AND ON-GOING. As noted in the Phase I SEA, such alternate uses may include small-scale application, on and off-grid, hydrogen storage methods, and how electricity regulation contributes to opportunities and constraints. This recommendation remains valid.**

Interactions with the Fisheries and other Marine Resource Uses		
Recommendation 18	Fisheries Database	The Province of Nova Scotia (a) assist DFO to develop and maintain a geo-referenced database of fisheries resources and activities to be used to determine where tidal energy development would have least impact on the fishery and other marine resource uses, and (b) develop a detailed study of potential tidal energy exclusion zone requirements by type of activity (including different types of gear use), potential impacts and possible mitigative strategies. **PARTIALLY ADDRESSED. Through OERA's Participation Support Fund in 2008, the Scotia Fundy Mobile Gear Fishermen's Association conducted a database search to document the fleet's activities and catches in the Bay, and carried out in-depth interviews with fishers to collect relevant traditional knowledge. DFO and NSE are working together on a Statement of Best Practices. DFO is currently reprocessing fish landing data to generate maps that will help show where different species are caught within the Bay. This recommendation remains valid.**
Recommendation 19	Compensation and Liability	The Province of Nova Scotia facilitate the development of a preliminary mitigation process to address compensation for fisheries displacement, damage to gear, and other environmental impacts, and limits to liability before any demonstration project proceeds. **PARTIALLY ADDRESSED. Although no formal mitigation/compensation process has been established by the Province, FORCE carries liability insurance which extends to all berth holders. In addition, environmental impacts are monitored (to the extent possible) on an on-going basis, and all berth holders are required to table decommissioning and restoration plans intended to return their sites to a natural state as possible. This recommendation remains valid.**
Recommendation 20	Aboriginal Fisheries	The Province of Nova Scotia require marine renewable energy proponents to engage with aboriginal communities at an early stage of project development to address issues and concerns, and facilitate discussion and information sharing. This engagement would be in addition to, and would not replace, the Province's duty to consult with First Nations. **ADDRESSED AND ON-GOING. Comment: this recommendation remains valid and is applicable to tidal energy projects in the Bay of Fundy. Early engagement for this SEA Update was initiated in the summer 2013 and discussion was completed in the fall 2013. Additional consultation is legally required during the Environmental Assessment process once a proponent declares an intention to proceed with a specific project. During the course of the current project, the Mi'kmaq Conservation Group expressed a strong desire to be more fully engaged by the Province on a regular basis. This recommendation remains valid.**
Recommendation 21	Fisheries Consultation and Involvement Protocol	The Province of Nova Scotia work with marine renewable energy proponents, local fishers and other fisheries interests to develop procedures and protocols to ensure that fishers and fisheries stakeholders are informed and consulted at every stage of tidal development, both by the Province

Interactions with the Fisheries and other Marine Resource Uses		
		and by proponents. **PARTIALLY ADDRESSED AND ONGOING. Although no formal procedures or protocols have been developed, the Province through OERA has participated in the engagement component of the updated SEA and other past tidal-related initiatives. FORCE has continued to include local fishers and Mi'kmaq representatives on EMAC, and supported a collaborative project between local weir fishers and researchers at Acadia University. This recommendation remains valid.**

Maximizing Regional and Community Benefits		
Recommendation 22	Marine Renewable Energy Benefits Strategy	Nova Scotia develop a Nova Scotia Marine Renewable Energy Benefits Strategy to ensure that the people of Nova Scotia benefit substantively from the development of these technologies. **ADDRESSED. The Marine Renewable Energy Strategy includes a benefits strategy for Nova Scotia residents. In addition, the *Community and Business Tidal Energy Development Toolkit* (ATEI 2013) presents benefits, opportunities and strategies for business and communities, although many of the benefits cannot be legislated or regulated as they occur through negotiation with the developer or as an "after effect" of development.**
Recommendation 23	Community Participation and Benefits	The Province of Nova Scotia, in consultation with municipalities, community development organizations, and other stakeholders, develop a Marine Renewable Energy Community Participation and Benefits Strategy to ensure the delivery of lasting socioeconomic benefits in the Fundy Region. **ADDRESSED. Again, the Marine Renewable Energy Strategy serves the purpose of a community participation and benefits strategy. In addition, the Province has initiated this activity through the COMFIT program and the Province's support (through OERA) of a community engagement handbook for COMFIT projects involving tidal energy..**

Other Marine Renewables		
Recommendation 24	Offshore Wind, Wave, and Tidal Lagoon Technology	The Province of Nova Scotia should apply the Sustainability Principles in Recommendation 1 to consider of all types of marine renewable energy technology. The Province of Nova Scotia should support a full Federal-Provincial panel review for any proposed tidal lagoon project. **NOT APPLICABLE AT THIS TIME because no formal proposal for a lagoon has been received. This recommendation remains valid.**

Integrated Management for the Bay of Fundy and Stakeholder Involvement		
Recommendation 25	Integrated Coastal Zone Management	The Province of Nova Scotia develop an Integrated Coastal Zone Management (ICZM) Policy for the Bay of Fundy before large scale commercial marine renewable energy developments are allowed to proceed. **NOT ADDRESSED. Comment: this recommendation remains valid. The Province currently uses the Coastal Management Framework to manage coastal areas and issued a Draft Coastal Strategy for public comment in 2011. Public comments were summarized and presented to the Province in 2012. Should commercial arrays be proposed, more focused ICZM planning may help to minimize overlapping claims and mitigate conflict. This recommendation remains valid.**
Recommendation 26	Geo-Referenced Tools to Indicate Opportunities and Constraints	Nova Scotia, New Brunswick and Canada collaborate to prepare and maintain geo-referenced tools to indicate opportunities and constraints for the full range of marine renewable energy technologies, to support the allocation of marine renewable resources within the context of an Integrated Coastal Zone Management Policy. **NOT ADDRESSED. This recommendation remains valid although New Brunswick has chosen not to development marine renewable energy in the Bay of Fundy at this time.**
Recommendation 27	Municipal Involvement	The Province of Nova Scotia consult with the Union of Nova Scotia Municipalities to develop procedures and protocols to ensure that municipalities are informed and consulted at every stage of tidal development, both by the Province and by proponents. **ADDRESSED. Although not addressed directly through the Union of Nova Scotia Municipalities, municipal representatives from Digby are consulted regarding tidal initiatives in that area. As part of the SEA process for the Bay of Fundy, municipal representatives from the County of Digby, Parrsboro, Windsor and Wolfville were notified of public engagement events. Other municipalities participated on the Stakeholder Roundtable. In summary, information sharing is ongoing with the municipalities; formal procedures and protocols do not appear to be required.**
Recommendation 28	Public Education and Awareness	The Province of Nova Scotia work with marine renewable energy proponents, research institutions and environmental and community organizations involved in sustainability education, to develop a strategy for public education and awareness about marine renewable energy technologies. **PARTIALLY ADDRESSED AND ONGONG. Since 2008 the Province has collaborated with research groups and industry to promote tidal energy development and have liaised (through OERA) with communities during the engagement process for the SEA update. No formal public education strategy has been developed. NSE frequently presents information at educational institutions (schools, community colleges and universities) and other events.** The **Tidal Energy Toolkit (AETI 2013) provides additional information. This recommendation remains valid.**

Integrated Management for the Bay of Fundy and Stakeholder Involvement		
Recommendation 29	Long-term Integrated Management in the Bay of Fundy	The Province of Nova Scotia, partnering with New Brunswick, Canada, and the Gulf of Maine Council, study ICZM requirements, approaches and experiences, to provide the background for a major workshop to be held in 2009 to examine integrated management issues and organizational options for the Bay of Fundy. **NOT ADDRESSED. No specific ICZM workshop focused on the Bay of Fundy has been organized since 2008. This recommendation remains valid.**