ORAL PRESENTATION ABSTRACTS

(in order of presentation)

Day 1

Marine Renewable Energy Potential in Coastal Cape Breton and the Bras d'Or Lakes

Dmytriw, R.
AECOM

On behalf of OERA, an AECOM team (CBU, the Unima'ki Economic Benefits Office, AMGC, Oceans and AECOM) prepared a Background Study identifying areas of interest (AOIs) for marine renewable energy (MRE) in Cape Breton. The Background Study is a reference report for the Strategic Environmental Assessment (SEA) that will help determine the future of MRE projects in Cape Breton. AOIs were selected based on the available energy resource and the MRE device technical & operating parameters. Wind and wave energy resource maps have been prepared for this region but the tidal resource is less well known. Four coastal tidal AOIs (Mabou-Cheticamp, Cape North-St. Paul Island, Scaterie-Flint Island, and Gabarus-Forchu) and two interior AOIs (Great Bras d'Or Channel and Barra Strait) were identified.

Current speeds in coastal areas are poorly mapped. Given the long coastline and numerous headlands that accelerate current speeds, the total energy is expected to be high; these areas are potentially suitable for tidal arrays. Conversely, there is an elevated potential for area use conflicts due to the variety of commercial fishing activities and the prominent social and economic value of these activities.

The Bras d'Or Lakes are a UNESCO site, a unique ecosystem and are widely used for recreation. Arrays may impede tidal flow resulting in far field energy extraction effects. Current speeds and thus total energy is low but adequate for technology demonstration, research and distribution of tide-generated electricity to local communities.

The Community and Business Tidal Energy Toolkit: Supporting Tidal Energy Development in Nova Scotia

MacDougall, S.[1,2] , **J.W. Colton**[2,3] and A. Howell[2]
[1] School of Business, Acadia University, Wolfville, NS
[2]Acadia Tidal Energy Institute, Wolfville, NS
[3] Community Development, Acadia University, Wolfville, NS

The Community and Business Toolkit for Tidal Energy Development was proposed in response to Nova Scotia's growing involvement in tidal energy development, coupled with its renewable energy targets. Focusing on both community-based and large-scale tidal energy development, the purpose of the Toolkit was to collect and synthesize what is known about tidal energy technologies under development, tidal flows in the Bay of Fundy, community and business impacts and opportunities, financing constraints, engineering challenges, and environmental, social and financial risks and how to mitigate them. *The Community and Business Toolkit for Tidal Energy Development* was the collaborative work of researchers from a broad range of disciplines (engineering, mathematics and statistics, biology, environmental science, finance, economics, sustainable communities, rural economic development), in consultation with community, industry and government stakeholders of tidal energy. The output is a comprehensive coverage of the issues, challenges and opportunities of developing tidal energy in Nova Scotia and elsewhere. It informs policy makers, municipal counsellors, device and project developers, financiers, community members and other users of the water, thereby empowering stakeholders and helping to ensure the development of tidal energy is environmentally, socially and economically sustainable. The development and release of toolkit is significant because no other document currently exists in the world that brings together the scientific *and* the socio-economic issues that reflect the reality of tidal energy development. Just as significant is the degree of collaboration among the many contributors from the university, private, and government sectors. The presentation provides a brief overview of its development and explores ways in which the toolkit can support sustainable tidal energy development.

Turbulence Measurement in High Speed Tidal Channels: Results from an Initial Experiment, and Future Directions

Hay, A.E., R. Cheel, J. McMillan and D. Schillinger
Ocean Acoustics Lab, Department of Oceanography, Dalhousie University, Halifax, NS

Results will be presented from a first turbulence measurement experiment in Grand Passage, NS, carried out in September 2012. The experiment was part of a wider effort to contribute to the knowledge base of flow conditions required for tidal power site assessment and development in Nova Scotia. Knowledge of turbulence is needed both near the sea bed, where stress on cables is an important issue, and in mid-water column at the so-called hub-height, where turbulent velocity fluctuations impact turbine design and performance. For this experiment, an instrumented lander was deployed on the seafloor. The deployment site, selected on the basis of high resolution mapping with multi-beam sonar, was characterized by coarse sand and gravel and shell hash molded by the flow into 8 m wavelength, nearly 1 m high dunes. On board the lander were two turbulence sensors: an acoustic Doppler velocimeter, and a time-of-flight acoustic flowmeter. An upward-looking Acoustic Doppler Current Profiler (ADCP) sampling at nearly 2 Hz was deployed nearby using a second lander. The presentation will include discussion of the flow and turbulence measurements in the bottom boundary layer and in mid-water column, highlighting those things which worked and those which did not, and leading to an outline of our plans for testing new approaches for turbulence measurement at hub-height during the upcoming field season.

Cross-coupling between Device-level CFD and Oceanographic Models Applied to TISECs in Minas Passage and Petit Passage

Klaptocz, V.[1], T. Waung[1], C. Crawford[2], M. Shives[2], **R. Karsten[3]**, C. Hiles[4] and R. Walters[4]
[1] Mavi Innovations Inc.
[2] University of Victoria
[3] Acadia University
[4] Cascadia Coast Research

Numerical models play an important role in assessing the resource potential of tidal races. In recently completed OERA funded projects, we examined and validated both Oceanographic and Computational Fluid Dynamics (CFD) models in order to improve techniques used for tidal resource modeling.

We began by examining the representation of turbines in numerical simulations. We evaluated the CFD model's ability to accurately predict thrust forces and wakes through comparison to flume tank experiments. The CFD model was then used to derive turbine performance parameters that are used in the Ocean model. Finally, the Ocean model was used to predict power produced by placing 16m-diameter turbines at each of the FORCE test berths.

Next we simulated the tidal flow in Petit Passage with a high resolution Ocean model that was validated against ADCP data. The ocean model output was used to drive a CFD model of the entire passage. The CFD simulations included a single 5m-diameter turbine in the passage, calculating the power extracted by the turbine over a tidal cycle and modeling the wake generated by the turbine.

The research established that a combination of Ocean and CFD models is required to accurately model tidal turbine arrays, if both the detailed flow around the turbine array and the large-scale tidal dynamics are being considered. Furthermore, the careful validation of a numerical model is important in quantifying its limitations. Understanding the capabilities of numerical models is critical as we undertake site assessment of both FORCE and Digby Neck locations.

Mapping the Bay of Fundy

Shaw, J., B.J. Todd and M.Z. Li
Geological Survey of Canada Atlantic, Bedford Institute of Oceanography, Dartmouth, NS

The Bay of Fundy, Canada has been systematically mapped twice by the Geological Survey of Canada. The 1977 surficial geology map depicts the sea floor in the context of the standard formations approach used on Atlantic Canada's continental shelf. The more recent mapping utilised multibeam sonar technology and resulted in a series of seventeen 1:50,000-scale maps of shaded seafloor relief (containing descriptions of geomorphology) and backscatter (containing descriptions of textural properties). A resulting series of journal papers (published and in press) highlighted the glacial history of the bay, the evolution of Minas Passage, the physical characteristics of the Minas Passage scour-trough system, the dynamics of the Scots Bay dune field, and the bedforms assemblages throughout the bay. The final product of the second phase was a 'Seascape' map, in which the seafloor was classified in terms of morphology, texture, and biota into eight broad classes: 1) bedrock; 2) glacial; 3) glaciomarine; 4) muddy; 5) scoured; 6) sandy; 7) biological, and 8) anthropogenic. Within the classes, many seascape units were identified, including 7 sandy seascapes that reflect the great variety of bedforms in the bay. The second phase of mapping reveals the great complexity of the seafloor and highlights the difficulty inherent in attempting to characterise the regional textural properties based on bottom samples.

Seasonal Change in Grain Size and Erodibility on a Tidal Channel-Flat Complex in Kingsport, N.S.

Law, B.A.[1, 2], T.G. Milligan[1], P.S. Hill[2], G.L. Bugden and V. Zions[1]
[1]Department of Fisheries and Oceans, Canada, Bedford Institute of Oceanography
[2]Department of Oceanography, Dalhousie University, NS

The extreme effect of energy extraction in the Bay of Fundy was demonstrated by reduction of tidal flow due to the construction of causeways in the late 1960's. Concern over possible change to the sediment dynamics in the Upper Bay of Fundy due to tidal energy extraction from in-stream tidal power, is warranted. In April 2012, a study funded by OERA was initiated to examine the seasonal change in grain size and erodibility on a tidal flat and channel complex in Kingsport, N.S. Sixty-two samples were collected for grain size analysis every month with 42 from the tidal flat and 21 from a tidal channel and its banks. Erodibility measurements were made monthly with a Gust microcosm erosion chamber on duplicate samples from the tidal flat, left and right tidal channel bank, and the channel thalweg. The monthly sampling was completed in March 2013. Results from this study will add to a baseline set of data being collected by researchers in the tidal power community, and it will provide the parameters necessary to run coupled sediment-hydrodynamic transport models. These models will be used to explore and quantify the possible effects of in-stream tidal power on the ecosystem. This talk will focus on the results from the OERA study and will also briefly describe a DFO lead Hudson cruise to the Minas Basin area, which is scheduled for June 2013.

Social Science Research in Marine Renewable Energy: Research Priorities Identified by the International Network for Social Studies of Marine Energy (ISSMER)

MacDougall, S.[1], J. Colton[1], S. Kerr[2], L. Watts[3] and K. Johnson[2]
[1]Acadia Tidal Energy Institute, Acadia University, NS
[2]Heriot-Watt University, Scotland, United Kingdom
[3]IT University of Copenhagen, Denmark

The inaugural meeting of the *International Network for Social Studies of Marine Energy (ISSMER)* took place in Stromness, Orkney, UK in September 2012. Funded by the UK Natural Environment Research Council, the purpose was to explore the social science research issues emerging in marine renewable energy. The researchers who attended were from around the globe and across the spectrum of social science research, ranging from fine art, history and sociology, to economics and finance. The participants gathered for focused conversations with local advocates, stakeholders and individuals affected by marine renewable energy development. The researchers then collaborated to identify the research themes emerging from the discussions and established a social science research agenda. The themes and the research agenda will be shared in this presentation.

DAY 2

Getting Plugged In: Assessment of Cable Lay Operations for Tidal Energy Developments in the Minas Passage

Steinke, D., A.J. Baron and D. Weaver
Dynamic Systems Analysis Ltd.

The laying of subsea electrical transmission and communications cables that will connect tidal energy turbines to the grid is key to the successful harnessing of the power of the world's highest tides. The Fundy Ocean Center for Energy (FORCE) is presently developing tidal energy infrastructure in the Minas Passage, including the installation of subsea cables. However, there is no direct experience in laying cables in the Minas Passage, so uncertainty and risks must be identified and addressed. There are many challenges associated with cable laying in the Minas Passage, such as: the short operational window, limited information regarding cable stability on the seabed, cable routing uncertainties, and seakeeping power limitations for conventional cable lay vessels or tug and barge outfits. However, it is difficult to address all of these challenges through limited sea trials and real-world tests. To reduce the risk of cable lay operations Dynamic Systems Analysis Ltd. (DSA) has worked with FORCE to simulate cable lay operations using its numerical modelling software ProteusDS. The analysis has assessed the expected loads on the cable lay vessel in both the extreme (flood and ebb) and expected deployment conditions. Additionally, the cable lay path and water column profile under the expected tidal currents during the cable lay operation were examined, and a preliminary assessment of cable stability on the seabed was conducted. Lastly, the potential for vortex induced motion in the cable was studied. The presentation will discuss the results of the study and review the key lessons learned.

Measurement of Long-Term Ambient Noise and Tidal Turbine Levels in the Bay of Fundy

Martin, B.[1], C. Whitt[1], C. McPherson[1], A. Gerber[2], M. Scotney[3]
[1]JASCO
[2]University of New Brunswick
[3]OMTS

JASCO Applied Sciences has been tasked with performing long term measurements of sound levels in the Bay of Fundy, at the Fundy Ocean Research Center for Energy (FORCE), where tidal current can exceed 6 m/s. The goal of the project is to measure sound levels while the turbines are operating at full tidal flow. In the fall of 2011 JASCO began deployments of its high flow mooring designed to minimize acoustic pseudo-noise associated with flow so that real acoustic measurements could be made. A variety of mooring configurations and hydrophone placements have been evaluated. This presentation discusses the mooring designs, the lessons learned from JASCO's deployments, and ambient noise data collected using the equipment. Computational fluid dynamics models of the acoustic and mechanical performance of one of the moorings performed by the University of New Brunswick will also be presented.

Sediment-Laden Ice: Is it a Serious Impediment to Subsurface Tidal Turbines in Minas Passage?

Sanderson, B.G., A.M. Redden and J. Broome
Acadia Centre for Estuarine Research, Acadia University, Wolfville, NS

The spectre of huge ice cakes drifting in the mid water-column has been proposed as a potential impediment to the operation of submerged tidal turbines. We conducted a study in which ice cakes have been sectioned, using hand tools, into multiple samples and Archimedes Principle used to measure densities. Such measurements have been made at multiple locations and at different times during two ice seasons. Density of frozen sediment was also measured. Measurements confirmed that highly stained ice cakes were very buoyant. Density of samples had a bimodal distribution, most being distinctly buoyant. A small number of samples incorporated intact frozen sediment (either rock or mud), which is distinctly more dense than seawater. Physical scaling requires that the larger an ice cake the more closely its density must match that of seawater in order for the ice cake to be entrained into the interior of the water column. Ice cakes are made from three types of material (ice, air pockets and sediment) two of which are much less dense than seawater and the other much denser. These disparate materials must be "assembled" in just the "right" combinations for a near neutrally-buoyant ice cake to result. Consideration of the sequence of mechanisms required to create a large, near neutrally-buoyant ice cake --- and consideration of the structural properties of ice cakes --- leads us to conclude that ice cakes do not pose a serious risk to well-engineered tidal turbines.

Criteria for Site Selection of Tidal Power in Stream Devices: The Importance of the Geological Environment

Fader, G.B.J. and **J. Mackie**
Atlantic Marine Geological Consulting Ltd.
Seaforth Geosurveys

Recent tidal power development in the Bay of Fundy began over six years ago and has progressed to the present stage involving deployment of tidal in-stream devices (TISEC), laying of seabed cables, and environmental and engineering monitoring. The criteria for site selection consisted of locating areas that provided appropriate water flow, seabed foundations, water depth, cable routes and a host of environmental concerns. The information collected for the geoscience component of site selection has revealed much about the characteristics and stability of the seabed of the inner Bay of Fundy in Minas Passage and Minas Channel. Areas of the strongest currents are scoured depressions cut into glaciomarine stratified sediments exposing bedrock. Remaining sediments consist of gravel in the granule to boulder range and mud and sand are absent. Instabilities exist along the northern shore of Minas Passage and sediment failures have been identified. To refine cable routes, a reprocessing and interpretation of all of the geoscience data has been recently undertaken on behalf of FORCE, to understand and quantify changes that have occurred over the past six years. This has provided a very high resolution understanding of seabed stability and characterization. Four test sites have been chosen for deployment of TISEC devices and within each are a variety of gravel and bedrock distributions and associated characteristics. It is important to emphasize that developers need to consider that scoured high energy regions present foundation challenges of gravelly sediments, bedrock and morphology, and that structures need to be designed to be flexible to cope with a variety of seabed conditions.

Intertidal Sediment Dynamics: Challenges, Lessons Learned and Potential Impacts of Tidal Power Development

van Proosdij, D.[1,2], C. O'Laughlin[1], E. Poirier[1], R. Mulligan[3] and L Ashall[3]
[1]Department of Geography, Saint Mary's University, Halifax, NS
[2]Intertidal Coastal Sediment Transport Research Unit, Saint Mary's University, Halifax, NS
[3]Department of Civil Engineering, Queen's University, Kingston, ON

The purpose of this paper is to examine the challenges, lessons learned and potential impacts of tidal power development on sediment dynamics within intertidal ecosystems in the Minas Basin. Hydrodynamics and resultant sediment deposition were recorded over a total of 92 tides over a 4 year period (2009-2013) at 3 sites ranging from an end member salt marsh tidal creek to an open marsh/mudflat system. Sedimentary processes (velocity and suspended sediment concentration) were recorded using a range of acoustic and optical instruments on the marsh surface and in the tidal creek. A minimum of 3 surface mounted sediment traps per instrument station were deployed with over 1000 filters recovered. One third of these filters were processed for Disaggregated Grain Size analysis using a Coulter Multisizer 3. Significant spatial and temporal variability were observed within all systems making it challenging to extrapolate empirical findings to areas outside of the field research site. Overall resolved horizontal velocities were low (5-10 cm/s tidal creek; < 5 cm/s marsh surface). However, velocities greater than 25 cm/s were recorded on the exposed mudflat during storm conditions. Suspended sediment concentrations were highly variable, ranging from 28 mg/l to 5,800 mg/l with highest amounts during storm conditions. Approximately 80% of this material was in flocculated form contributing to almost 7 times more deposition within the creek as compared to the vegetated surface. Results are contributing directly to hydrodynamic and sediment modeling exercises and preliminary models examining the potential environmental effects of tidal energy extraction will be presented.

Development of Temporal Monitoring Techniques for Benthic Habitat Impacts of Tidal Energy

Brown, C.J.[1,2], D. Tzekakis[1,2], U. Lobsiger[1] and R. Devillers[2]
[1]McGregor GeoScience Ltd., Bedford, NS
[2]Memorial University, St. John's, NL

Deployment of Tidal in Stream Energy Conversion (TISEC) devices, including turbines and cables, may impact benthic habitats through the alteration of environmental conditions with subsequent impacts on benthic productivity and diversity. *In situ* sampling methods (e.g. sediment sampling) have been traditionally used to monitor marine habitats with respect to human impacts. However, these methods lack data density and spatial coverage to accurately define habitat heterogeneity and variability across meso- (10 m^2 – 1 km^2) and broad-scales (>1 km^2). Acoustic mapping devices, (e.g. multibeam echosounders), can ensonify broad scale areas with 100% spatial coverage at sub-meter resolutions in shallow coastal waters. Recent developments in acoustic classification methodologies may offer a cost-effective approach for detecting change in seafloor conditions when applied to data from repeat acoustic surveys over the same area. When coupled with the collection and analysis of conventional seafloor sampling techniques (i.e. benthic grab samples and underwater video), this combination of survey methods may offer a suitable approach for monitoring change associated with the deployment of TISEC devices in the marine environment. In the spring of 2012, repeat inter-tidal acoustic and seafloor sampling surveys were conducted over 4 case study sites in the Bay of Fundy as part of an OERA funded research program to assess physical/biological changes in seafloor features over various time-frames. The same areas will be surveyed again in the spring of 2013 to assess any inter-annual changes in seafloor conditions at these sites. Preliminary result suggest these techniques offer potential to measure

broad-scale changes in environmental conditions at the seafloor, and an overview of this project to date will be presented.

Assessment of Zooplankton Injury and Mortality Results from Two Deployments of Underwater Turbines for Tidal Energy Production

Schlezinger, D.R.[1], C. D. Taylor[2], R. I. Samimy[1] and B. L. Howes[1]
[1]University of Massachusetts, Dartmouth; School for Marine Science and Technology
[2]Woods Hole Oceanographic Institute, Department of Biology

Collaborative work between the UMASS-Marine Renewable Energy Center, the Town of Edgartown and the Coastal Systems Program is focused on developing the tidal energy potential of Muskeget Channel. We have undertaken detailed oceanographic and environmental surveys to optimize in-stream turbine power generation and to quantify potential environmental effects. In 2011 and 2012 tidal turbine demonstration projects were conducted in Muskeget Channel to determine the effects of blade strikes, shear stress, turbulence, and cavitation on zooplankton. Single turbines may minimally impact zooplankton populations; however, full scale projects may potentially alter zooplankton populations forming the base of coastal food webs. Static plankton tows were performed up and down stream of the operating turbine axis. Integral flow meters allowed adjustment of tow duration to optimize zooplankton density in the concentrate. Samples were held at *in situ* temperatures and sequential photomicrographs and video images were taken to determine particle density, size distribution and the number live organisms in samples taken up and down gradient of the operating tidal turbine within 3 hours of collection. Statistical analysis showed no significant difference in the total number or size distribution of motile zooplankters indicating tidal turbine operation did not cause significant mortality or changes in viability and suggested that impacts of commercial size tidal energy projects upon zooplankton populations in Muskeget Channel may be negligible. Future work will focus on regions of higher current velocities where turbine induced stresses may be greater and determining whether cumulative or synergistic effects may occur in commercial deployments of multiple turbines.

Use of Hydroacoustic Telemetry to Detect Movements of Migratory Fishes and Lobsters in the Minas Passage

Redden, A.M.[1,2], J. Broome[1,2], F. Keyser[1,2], K. Morrison[1,2], M. McLean[1], R. Bradford[3] and M.J.W. Stokesbury[1]

[1] Biology Department, Acadia University, Wolfville, NS
[2] Acadia Centre for Estuarine Research and Acadia Tidal Energy Institute, Acadia University, NS
[3] Fisheries and Oceans Canada, BIO, Dartmouth, NS

Tidal energy developments at the FORCE site in the Minas Passage have necessitated research to help determine the potential risk of turbine – marine biota interactions. Since 2010, we have been collecting data on the Minas Passage movements of significant species, including those that have been listed as endangered (striped bass), of high conservation significance (Atlantic sturgeon), of special concern (American eel) and of high commercial value (American lobster). Our project uses VEMCO animal tracking technology to track animal movements and behaviour over a scale of kilometres. Receivers placed in lines across both the passage (5 km wide) and the FORCE test site are being used to detect electronic tags surgically implanted in fish, as well as those attached to the carapace of lobsters, to determine how migratory species use the Minas Passage as they migrate into and out of the Minas Basin on a seasonal basis. Results show that the FORCE test area forms part of the migratory corridor for both lobster and fish. Many fish have been shown to make multiple, near daily passes through the passage. Depth within which fish swim varies with species and, for striped bass, varies with maturity. The biggest challenges faced to date are: 1) limited receiver detections of transmissions when ambient noise levels are very high (average water column current speeds >2.5 m/s); and 2) mooring technology and equipment durability (strain at attachment points) and unit movement in high flow environments.

Passive Acoustic Monitoring of Harbour Porpoise at the FORCE Site in Minas Passage

Wood, J.D.[1], D.J. Tollit[2], A.M. Redden[3], J. Broome[3] and L. Fogarty[3]
[1] SMRU LLC, Friday Harbor, WA
[2] SMRU Ltd. Canada, Vancouver, BC
[3] Acadia Centre for Estuarine Research and Acadia Tidal Energy Institute, Acadia University, NS

Currently, there is sparse information available on the near-field effects of tidal in-stream energy conversion (TISEC) devices on marine mammals. There is also little data on the temporal presence and activity of marine mammals in the upper Bay of Fundy. Harbour porpoise are listed by COSEWIC as a species of special concern and represent the most commonly occurring species of cetacean in Minas Passage/Basin, seen year-round in small pods. While the risk of direct collision or turbine strike remains a potential concern for marine mammals, behavioural or activity level modifications or loss of foraging habitat due to anthropogenic noise disturbance (notably noise during TISEC turbine operation, but also during any foundation construction) and indirectly due to changes in prey populations (such as reef effects due to TISEC turbine presence) are considered two significant data-gaps that need biological assessment. C-POD hydrophones (autonomous cetacean echolocation click detectors) have been deployed in and around the FORCE site since 2010 to determine baseline activity patterns of Harbour porpoise and how these vary over time and space. Data indicate daily presence of porpoise in Minas Passage at typically low levels from May through November. Porpoise detections vary significantly across time and space. Porpoise detections are highest at night time as well as during the months of July and November. Porpoise detections also vary across relatively small spatial scales (~700m). The unique challenges of collecting acoustic data in tidally dynamic sites will also be discussed.