FERN

FUNDY ENERGY RESEARCH NETWORK

Annual Newsletter

Issue 5 | Winter 2016

What's Inside...

Sponsored by

FORCE Fundy Ocean Research Center for Energy

NOVA SCOTIA Department of Energy

and hosted by

ACADIA CENTRE FOR ESTUARINE RESEARCH

ACADIA UNIVERSITY

Photo Credit: Darren Pittman/Images East Photography

Assembly of the 2 MW turbine to be deployed by Cape Sharp Tidal in the Minas Passage in spring 2016

Message from the FERN Executive

On behalf of the FERN Executive Committee, I am pleased to present the latest issue of the FERN Annual Newsletter. FERN continues to serve as a primary forum for cross-sector sharing and discussion of information and ideas, and the development of partnerships in research, outreach and other tidal-energy related activities. The past year has been a busy one for the academic, government and industry sectors, as demonstrated in the various articles included in this issue. We hope that you will find this newsletter both interesting and informative. In the coming months, we'll see deployments of the first grid connected, large-scale, tidal turbines at FORCE. Stay tuned — the year 2016 promises to be exciting!

Anna Redden

Chair, FERN Executive (anna.redden@acadiau.ca)

FERN's Mission:

To foster research collaboration, capacity building and information exchange to advance knowledge, understanding and technical solutions related to tidal energy development in the Bay of Fundy.

FERN Activities and Accomplishments

Dana Morin presenting FERN Socio-economic Subcommittee accomplishments at the October 2015 FERN AGM

2015 Annual General Meeting

The 2015 FERN AGM was held at the K.C. Irving Environmental Science Centre at Acadia University on October 28. Members were welcomed and thanks were extended for the many contributions of members and to Gregory Heming for serving as Executive committee co-chair from Oct 2014 - Oct 2015. The FERN objectives were reviewed to reflect on how well FERN is meeting its objectives and serving member needs since FERN was established in 2010. Subcommittee chairs provided overviews of their committee activities and accomplishments in 2015 and planned directions for 2016. Representatives from FORCE and the Digby area COMFIT sites reported on their research and monitoring activities and a representative from Cape Sharp Tidal gave an update on their activities.

We thank **Cape Sharp Tidal** for generously sponsoring the FERN AGM coffee break.

FERN Executive Committee for 2015/2016

Executive Committee Chair:
Anna Redden, Acadia University

Engineering SubCommittee Co-Chairs:
Tiger Jeans, University of New Brunswick
Dean Steinke, Dynamic Systems Analysis Ltd.

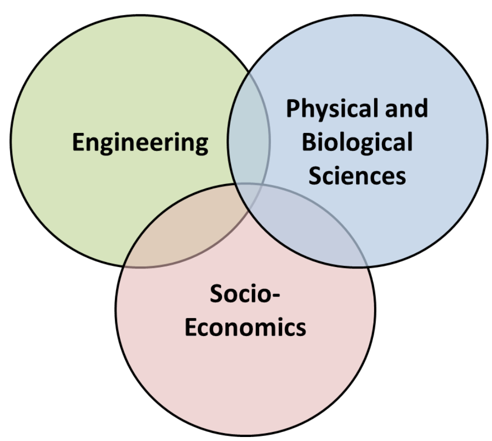
Natural Sciences SubCommittee Co-Chairs:
Graham Daborn, Acadia University
Brent Law, Fisheries and Oceans Canada, BIO

Socio-Economics SubCommittee Co-Chairs:
Dana Morin, Fundy Tidal Inc.
John Colton, Acadia University

Subcommittee Highlights

FERN's three subcommittees represent the core tidal energy research themes: **Engineering, Socio-Economics** and the **Natural Sciences (biological and physical).** The network's Executive committee consists of a chair, and the two co-chairs from each of the three subcommittees. Members from academia, government, industry and various other organizations sit on all three subcommittees providing a diverse set of interests and expertise to foster collaboration, to communicate research findings and to identify and resolve priority issues related to tidal energy. Some highlights from the subcommittees during 2015 included:

- Development of a tidal energy communication activities survey and a communication and engagement matrix;
- Guest speaker series highlighting recent research in tidal energy followed by in-depth Q&As;
- Identifying funding and collaboration opportunities among members; and
- Foundational research activities to address gaps in the biological and physical characterization of high flow marine areas in the Bay of Fundy.



FERN Activities and Accomplishments

Scope of FERN Member Activities

- Representation on regional, national and international MRE committees (IEC TC-114, OES- Annex IV, MRC, FORCE, OERA, EMAC, etc.);
- Project collaboration and capacity building;
- Participation in local, national and international conferences, workshops & symposia;
- Progress reporting on FORCE's FAST program;
- Support for students & young professionals;
- Database maintenance and updates on tidal energy research in the Bay of Fundy; and
- Contributions to various projects and reports.

Plans for 2016

- Expand the FERN Network with researchers and other tidal energy stakeholders and institutions regionally, nationally and internationally;
- Quantify the socio-economic benefits of the first tidal energy feed-in-tariff projects;
- Further develop the FERN website and its content and functionality;
- Solicit the FERN membership for feedback on network activities and areas for member benefit improvement; and
- Continue to identify and address gaps in knowledge related to tidal energy development.

FERN Membership at a Glance

167 Registered members

87 Institutions

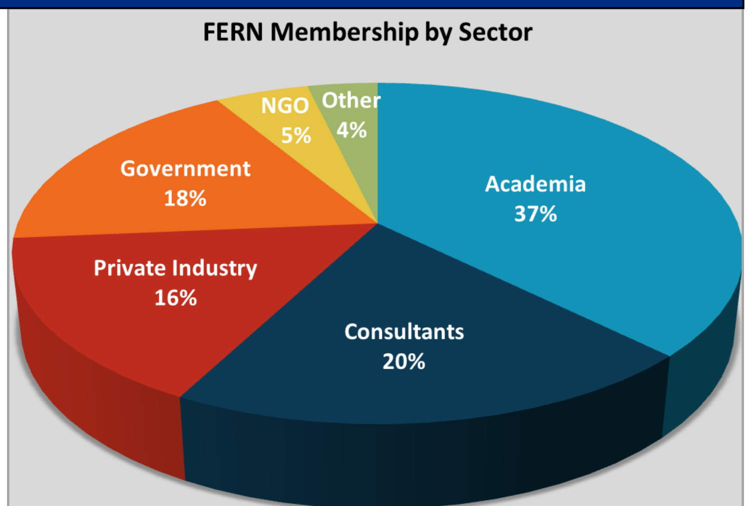
8 Canadian Provinces

7 Nations

BECOME A MEMBER

FERN

Keep informed! Membership is free!



Map Credit: Elizabeth Nagel

Nova Scotia Department of Energy

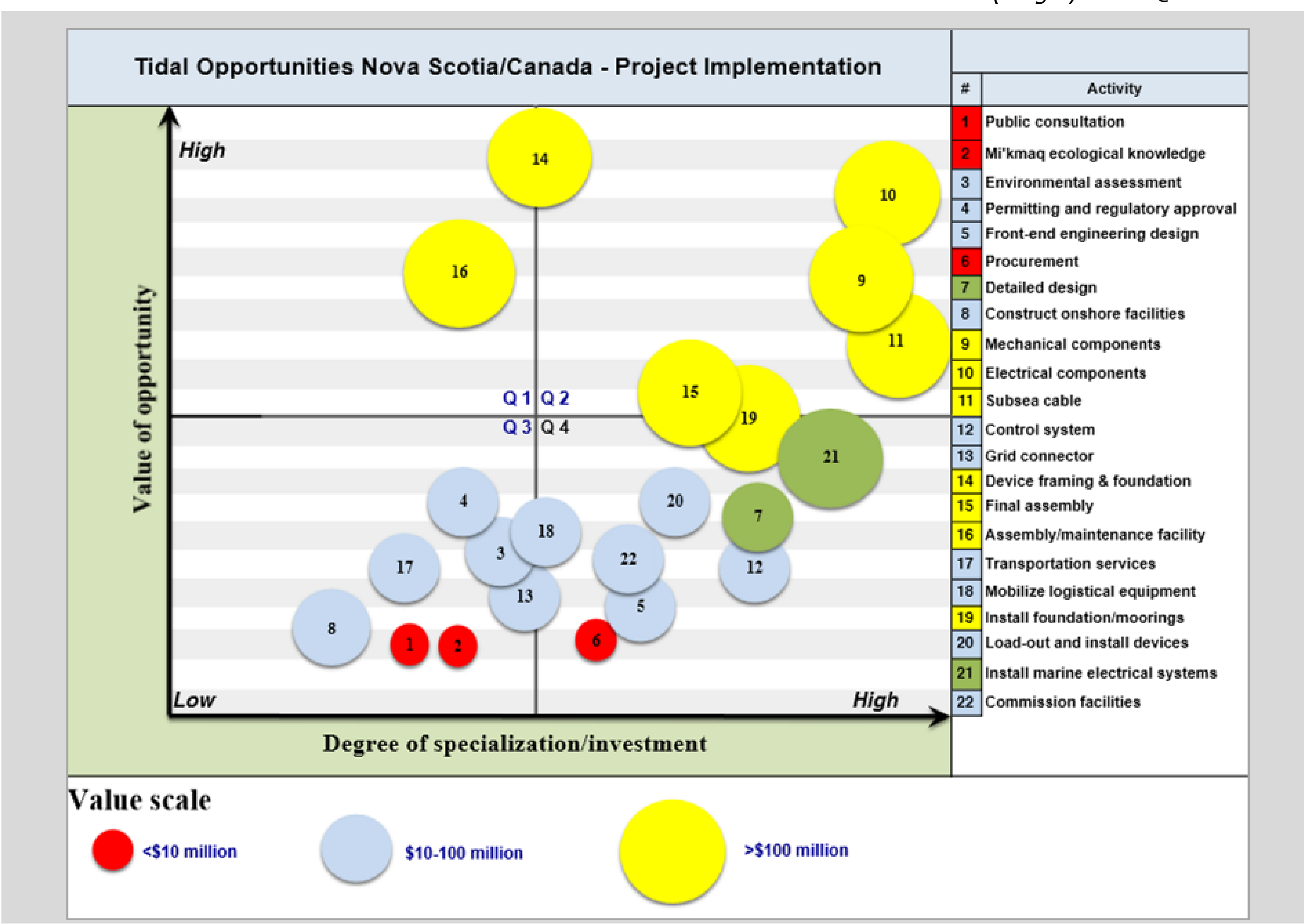
The past year was yet another significant year for tidal energy's development in Nova Scotia. In April, the Province introduced its Marine Renewable-energy Act, which outlines a clear, predictable, and efficient process to support the responsible growth of the sector. It will do this in such a way that will protect the environment, respect community and local needs, and ensure that Nova Scotians benefit. This legislation represents a key step forward as Nova Scotia prepares for large-scale deployments in the coming years.

The year 2015 also saw significant research continue in the Bay of Fundy. With the Offshore Energy Research Association, we have announced two successful projects that will strengthen ties with our partners in the United Kingdom and further our leadership in environmental sensing and monitoring. We have also sponsored research to identify the next areas for development within the Bay Fundy—the results of which will help regulators to ensure commercial developments happen in a sustainable and responsible manner.

Also in April, we saw the release of the study, "Value Proposition for Tidal Energy Development in Nova Scotia, Atlantic Canada and Canada" commissioned by the Offshore Energy Research Association. The study shows how tidal energy could reduce our dependence on fossil fuels and create a new industry that offers significant socio-economic benefits across the nation. Over the next twenty-five years, the tidal energy industry could contribute up to $1.7 billion to Nova Scotia's gross domestic product (GDP), create up to 22,000 full time positions and generate as much as $815 million in labour income, according to the study.

In summer of 2015, we announced a renewal of our cooperation with the Government of British Columbia on tidal energy. We recognize the importance working with our national partners to solidify Canada's leadership in the global tidal energy sector.

Gregory Decker,
Senior Engineer, Nova Scotia Department of Energy
(Gregory.Decker@novascotia.ca)



Opportunity assessment for industry participation. Figure taken from the Value Proposition for Tidal Energy Development in Nova Scotia, Atlantic Canada and Canada. This document can be accessed at http://www.oera.ca/marine-renewable-energy/tidal-research-projects/other-tidal-research/value-proposition-for-tidal-energy-development/

Offshore Energy Research Association

Transatlantic environmental monitoring solutions

Canadian and British researchers are joining forces to collaborate on two projects in developing new environmental sensing technologies for tidal energy applications. The two projects worth a combined $1.43 million were selected for funding through a joint research competition managed and funded by the Offshore Energy Research Association (OERA), and Innovate UK, a government funded business and innovation accelerator out of the United Kingdom.

The first collaborative project, led by Emera Inc. of Halifax, Nova Scotia, will deliver a new monitoring system that will integrate passive and active acoustic sensor technologies to improve real-time detection and tracking of fish and marine mammals at tidal sites in the Bay of Fundy. For the first time here in Nova Scotia, the project will integrate the *icListen* smart hydrophone technology developed by Ocean Sonics Ltd. of Great Village, Nova Scotia, with the UK's Tritech Ltd. *Gemini* imaging sonar system. Combining the complementary technologies will enhance species detection, tracking and classification capabilities. The project's marine biology expertise will be provided by Acadia University, and the Sea Mammal Research Unit's (SMRU) Canadian and British offices. The project will be completed in early 2018.

The second project, led by Rockland Scientific Inc. (RSI) of Victoria BC will develop a new sensor system to measure the impact of turbulence on tidal devices. Project partners are Dalhousie University, Black Rock Tidal Power (BRTP), along with United Kingdom based Flo Wave TT, European Marine Energy Centre (EMEC), and Ocean Array Systems (OAS). Project results will be used to improve turbine design and operational performance, as well as contribute to characterizing optimal turbine installation sites.

Laboratory and field testing will be carried out in three locations. First at the Flo Wave lab facility in Edinburgh, followed by deployments at EMEC in Orkney, Scotland and at the FORCE site in the Bay of Fundy. The data sets from all measurement locations will be compared against each other and analyzed for turbulence flow structure. The project will be completed in late 2017.

Optimizing tidal development areas in the Bay of Fundy

In late 2015, the OERA executed a competitive research call to undertake a new tidal resource characterization study for the Bay of Fundy. The project will yield a comprehensive digital map series for use in supporting the recently tabled *Marine Renewables Energy Act*. More specifically, the proposed work will help identify areas where (in-stream tidal) renewables projects may be developed in the future. These designated areas, known as 'Marine Renewable Electricity Areas' or MREAs, will provide clarity on the use of marine space, that together with other significant research and consultation, will ensure the responsible and sustainable use of the Bay of Fundy resource in the years to come.

The project team will develop a digital map series using a Geographical Information System (GIS) platform, to identify new in-stream tidal resource opportunities *outside* the FORCE Crown Lease Area in the Bay of Fundy. The project will build on existing numerical modeling work, and will consider multiple factors, site constraints and opportunities to help identify regions suitable for tidal resource development. Examples of the types of constituents that will be modeled include: extractable power; different device specifications; seabed characteristics; distance from environmentally sensitive marine ecosystems; turbine density impact; proximity to electrical infrastructure (existing/planned); other resource uses such as fisheries, aquaculture, transportation; as well as First Nations interests, to name a few.

The mapped data and modeling outputs will be compiled to create a digital atlas. The atlas will be designed for use as an interactive tool, allowing 'visualization' of the resource potential, constraints and opportunities in characterizing optimal in-stream tidal development MREAs. Further information on this project can be found at on the OERA website, www.oera.ca. The project is expected to be completed in 2016.

Jennifer Pinks
Research Manager, OERA (jpinks@oera.ca)

Photo Credit: Meghan Swanburg

FORCE: 2015 Highlights

Electrical Upgrades

In December 2014, all four FORCE developers received approval through Nova Scotia's developmental feed-in tariff program for a total of 17.5 megawatts (MW) of electricity:

- Minas Energy, 4 MW
- Black Rock Tidal Power, 5 MW
- Atlantis Operations Canada, 4.5 MW
- Cape Sharp Tidal Venture, 4 MW

The approval allows the developers to enter into a 15-year power purchase agreement with Nova Scotia Power.

In 2015, FORCE began feasibility and impact studies, approvals, permitting, and electrical design work to expand onshore electrical infrastructure to accommodate up to 20 MW to allow small turbine arrays to connect to Nova Scotia's electricity grid.

This will involve a process to create detailed design and specifications, as well as to purchase and install new substation equipment. Tenders related to upgrade purchasing are posted online: http://fundyforce.ca/media-center/opportunities/

Data & Research

FORCE has completed construction of two underwater platforms created for the Fundy Advanced Sensor Technology (FAST) platform program, designed to collect information on the marine environment. Some of the Nova Scotia companies involved include Open Seas Instrumentation Inc., EMO Marine Technologies Ltd., and Mackenzie Atlantic Tool and Die Ltd. FAST has two critical roles:

1) to better characterize and validate tidal resource sites, and
2) to better monitor the environmental conditions.

FAST responds to an emerging industry need to provide better methods to gather data under the extreme conditions of high flow tidal races.

Both platforms have been deployed in the Minas Passage. The smaller platform has been collecting live data from the Minas Passage, which can be viewed at the FORCE site. FORCE also conducted mooring trials during peak flow tides in the Minas Passage. These trials help prepare for safe and cost efficient technology deployments, and lay the groundwork for more complex future operations.

1) FORCE Visitor Centre; 2) FAST-1 in Parrsboro's intertidal zone; 3) FORCE's Murray Scotney + Dominion Diving crew test the FAST-1 monitoring platform in the Minas Passage; 4) FAST-2 is tested at the FORCE site.

Photo credits: FORCE

FORCE: 2015 Highlights

As part of the FAST program, FORCE completed phase one of the Vectron project (with partners Nortek Scientific and Dalhousie University) which will offer high resolution current data from turbine hub height, critical to successful device deployment and operation. FORCE also conducted a survey of the FAST data cable, establishing useful methods and equipment for monitoring and maintaining our subsea assets.

Shore-based monitoring systems have also been integrated at FORCE, including X-band radar and the meteorological tower with our tide gauge offshore, providing a multi-dimensional understanding of our real-time operating environment. This data is online: http://fundyforce.ca/environment/live-weather-data/

FORCE launched a new collaboration with Ocean Networks Canada (ONC) to support the FAST program by enhancing the accessibility of its data to the public, scientists and developers around the world. Our onshore data is already accessible online, including a time-lapse video from the previous day: http://fundyforce.ca/visit/live-video/

FORCE and its partners also released new radar imaging as part of a program to more efficiently characterize high flow sites. Results will be critical towards assisting FORCE and developers in determining placement of turbine arrays and associated marine infrastructure in the Minas Passage.

FORCE also partnered with Acadia Tidal Energy Institute (ATEI) and Tekmap Consulting to create a new tidal energy geographic information system (GIS) mapping platform. This platform gathers physical, environmental and infrastructure data from tidal sites along the Bay of Fundy and makes this information accessible online. The tool will aid in decision-making related to research, development and deployment by yielding insights such as the visualization of physical and environmental layers of a site, available power potential, existing turbulence and the presence of marine life. The GIS tool allows industry, government, scientists and the public to look at many of these variables quickly and easily - looking at power potential, grid access, environment, and other data of interest all in one place.

When launched, the GIS tool will help to build a sustainable tidal energy industry across the province as well as provide educational benefits for the broader community.

Environmental Effects Monitoring (EEM) Program

FORCE has been designing a new EEM program to track effects of turbines on our environment – part of FORCE's core mandate. Work is now underway in anticipation of next turbine deployment. The new EEMP is based on review of past studies, with input from discipline experts, an external consultant and our Environmental Monitoring Advisory Committee (EMAC).

The second EEMP report, covering studies to 2013, was completed and is now available online here:
http://fundyforce.ca/environment/monitoring/

As part of an effort to protect fishing activity, as well as protect FORCE assets and avoid cable liability, FORCE has created a safety zone 500m around the subsea cables – a standard distance for an offshore safety zone. FORCE also created a new Fishers' Liaison Group in 2015 as a forum to share information directly with interested fishers.

Matt Lumley
FORCE Communications Director
(Matt.Lumley@fundyforce.ca)

FORCE welcomed 5,400 guests to their visitor centre in 2015, bringing the total to almost 19,000 since 2012.

Research at Small-Scale Tidal Sites

Fundy Tidal Inc continues to work with several research collaborators on tidal site characterization, turbine siting, and environmental monitoring. Our technical work receives support from federal and provincial funding, and includes assisting with the development of tools and techniques required to advance the industry, while also meeting information needs for our Digby Gut, Petit Passage, and Grand Passage COMFIT projects.

Fundy Tidal continues to operate a small office in Freeport, which provides a base of operations for on-water and in-community project development work. The office provides a prime location for discussions on tidal energy development, as well as shelter, power, and high-speed internet along the Grand Passage shoreline. The cabled ADCP (deployed July 22, 2014), CO_2 sensor, and CTD sensors have been maintained and continue to stream data to Dalhousie University. Working with Ocean Sonics we deployed a cabled icListen hydrophone, with data streaming online from late August through November 2015.

Significant effort is currently applied to: a) micro-siting turbine locations and forecasting energy production for different technology options, and b) reducing uncertainties relevant to the design and operation of tidal power systems. This includes:

- detailed oceanographic data collection, processing, and review with Dalhousie University (flow velocities, turbulence, waves, and seabed);
- modelling flow conditions with Acadia University (using FVCOM), University of New Brunswick (CFD), and Mavi Innovations (CFD);
- modelling wave conditions with Cascadia Coast Research (SWAN)
- predicting turbine energy production with Acadia University and several turbine developers; and
- predicting tidal system response to flow and waves conditions with Dynamic Systems Analysis (ProtusDS).

Our research group recently received funding to deploy and monitor a floating platform in Grand Passage during January/February 2016. The goal is to reduce costs and risks associated with moorings and floating systems for tidal energy projects. The study will evaluate the response of the platform, mooring lines, and anchors to different wind, wave, and tidal conditions. Measured system response will be compared to dynamic analysis conducted by DSA. The floating platform and mooring system could be available for use in future research projects.

Fundy Tidal has continued to conduct the marine life observation program at all 3 COMFIT project sites. This program has created five local jobs, and provides baseline information needed for developing monitoring plans and evaluating potential environmental effects of tidal energy development. Chloe Malinka analyzes the data from Scotland, where she works as a research assistant with the SMRU. Fundy Tidal is working with Anne Lombardi (PhD student with Dr. Alex Hay) to a) characterize natural noise conditions using moored and drifting passive acoustic hydrophones, and b) use multi-channel hydrophones to localize sound sources. Fundy Tidal is working with Dr. Moira Brown and several locals to help re-establish a whale disentanglement team based out of the Brier Island and Long Island area.

For more information on Fundy Tidal's research activities and/or to discuss opportunities to collaborate, please contact Greg Trowse.

Greg Trowse
Chief Technology Officer, Fundy Tidal Inc.
(gtrowse@gmail.com)

Photo Credit: Dean Steinke

Left:

The ecoSpray tidal energy test platform in Grand Passage.

Bottom:

FTI Research and monitoring site office, Petit Passage.

Photo Credit: Greg Trowse

Tidal Research in Maine

The Fisheries Assessment Survey Team (FAST) at the University of Maine, School of Marine Sciences, has spent much of their time in 2015 processing and analyzing data collected from 2011-13 around the TidGen® device and in 2014 around the OCGen® device. Both of these were deployed by Ocean Renewable Power Company (ORPC). We have several datasets from different monitoring methods. We used our long-standing stationary, down-looking hydroacoustic surveys along with stationary side-looking hydroacoustics near the bottom support frame of the TidGen® that was deployed in 2012. We also used mobile down-looking hydroacoustic surveys to study fish behavior as they approached the deployed OCGen® device.

The analyses associated with the aforementioned data collection have led to three recent publications. The stationary side-looking hydroacoustics data near the TidGen® bottom support frame have been collected constantly for over one year. This provided a nearly continuous record of fish detections at the site, which has been used to determine major patterns in fish abundance. Preliminary analyses of a subset of this time series show that fish abundance changes on multiple time scales, including tidal, daily, and potentially lunar cycles (Viehman and Zydlewski 2015). We are now looking for longer-scale patterns in the full year of data (e.g., seasonal cycles) that we just completed collecting. Understanding the natural patterns in fish abundance at this tidal energy site will allow us to design long-term monitoring programs which will provide more accurate observations of fish abundance (and therefore better detection of turbine effects), while using fewer individual surveys.

The combination of the stationary and mobile down-looking hydroacoustics data have enabled us to estimate the chances of fish being at the same depth as, or encountering, a tidal energy device. This "probability of encounter" model provides proportions of detected fish in the area around the turbine that could potentially encounter the whole device or just its moving components (Shen et al. 2015). These data will help inform a larger model being developed by Argonne National Laboratory and the USACE Engineer Research and Development Center that will include the influence of the hydrodynamics around the turbine on fish.

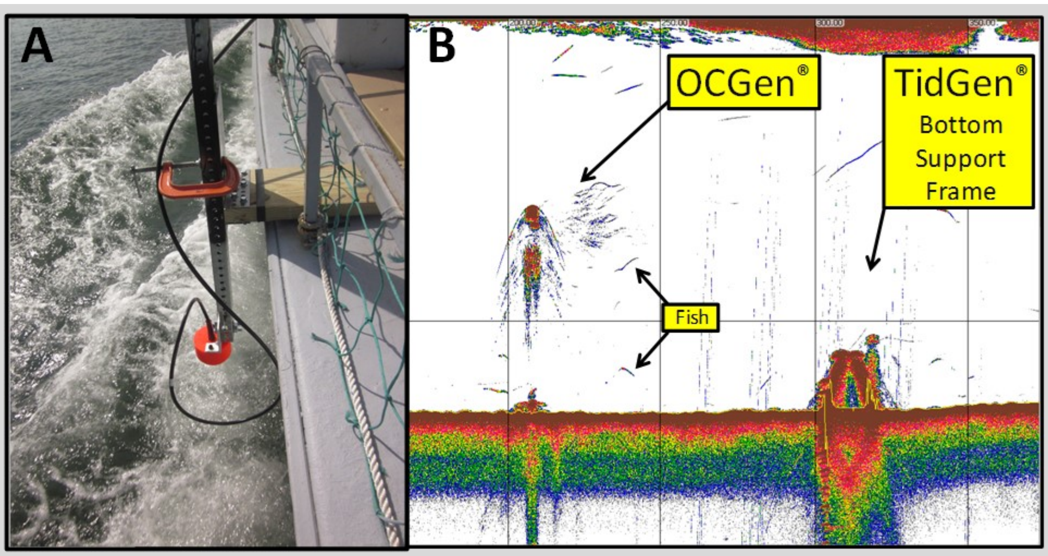
Analyses have been performed on the stationary down-looking dataset (2011-2013) collected before and after the TidGen® was installed. These data also included surveys from a control site as part of a Before-After-Control-Impact (BACI) design. This allowed us to compensate for any natural changes in fish abundance or distribution that may have been site specific or related to annual variation, providing more confidence in our findings. We were able to detect differences associated with the presence of the TidGen® in two of three separate BACI comparisons of how fish use the water column near the device (vertical distribution) and the overall biomass of fish in the area (Staines et al. 2015).

Garrett Staines, Haley Viehman, and Gayle Zydlewski
University of Maine, School of Marine Sciences
(gayle.zydlewski@maine.edu)

Shen, H., Zydlewski, G., Viehman, H., and Staines, G. 2015. Estimating the probability of fish encountering a marine hydrokinetic device. Proceedings of the 3rd Marine Energy Technology Symposium (METS), Apr. 27-29, 2015, Washington D.C.

Staines, G., Zydlewski, G., Viehman, H., Shen, H., McCleave, J. 2015. Changes in vertical fish distributions near a hydrokinetic device in Cobscook Bay, Maine, USA. Proceedings of the European Wave and Tidal Energy Conference, 6-11 September.

Viehman, H., and Zydlewski, G. B. 2015. Using temporal analysis techniques to optimize hydroacoustic surveys of fish at MHK devices. Proceedings of the European Wave and Tidal Energy Conference, 6-11 September.



(A) Mobile down-looking hydroacoustics mounting apparatus attached to research vessel; and (B) hydroacoustics data echogram displaying depth vertically and time horizontally during a mobile transect on a flooding tide while passing over both the OCGen® and the bottom support frame of the previously deployed TidGen®.

Acadia Tidal Energy Institute (ATEI)

The Acadia Tidal Energy Institute (ATEI) is a non-profit organization conducting tidal energy research, training, education and outreach. In 2015, ATEI members worked on a range of projects to address data and information gaps. Through risk reduction and informed decision making, these projects will contribute to sustainable tidal energy developments in Nova Scotia.

Nova Scotia Tidal Energy Atlas

ATEI, in partnership with ACOA, DoE, OERA, FORCE and Tekmap Consulting, has continued to develop the Nova Scotia Tidal Energy Atlas, an interactive web mapping application that makes tidal energy related spatial information readily accessible to the public. The Atlas will be released in early 2016.

ATEI Director Anna Redden speaks with the Honourable Scott Brison following the ACOA funding announcement of the Nova Scotia Tidal Energy Atlas project, on July 3, 2015 at Acadia University.

Community Engagement Strategies

ATEI members and students have been active in exploring how community engagement strategies influence stakeholder perspectives on tidal energy development in Nova Scotia. This project explores tidal energy development in three areas in Nova Scotia, comparing and contrasting different stakeholders strategies, and examines to what extent these strategies support social acceptance of tidal energy development.

Testing Sensor Technologies

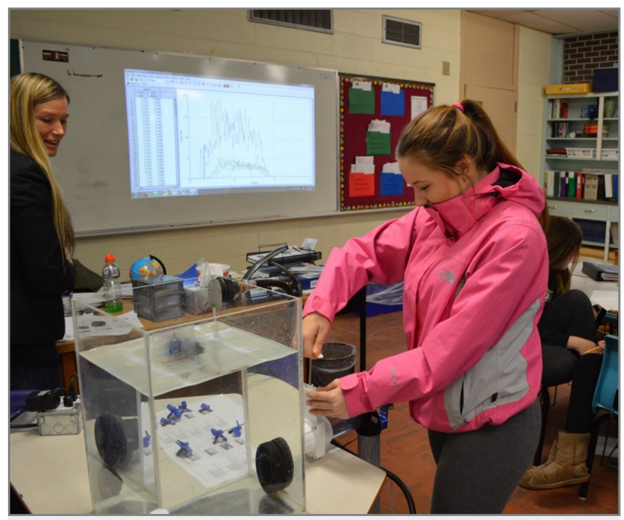
In 2015, Acadia researchers conducted field studies to examine fish detection performance characteristics of a Gemini imaging sonar for a new project to advance acoustic environmental sensors and software for the detection of fish and marine mammals at and near tidal energy turbines. This OERA-UK Innovate funded project is a partnership with Emera (Lead PI), Ocean Sonics, Open Hydro Technology Canada, Tritech, SMRU Canada and SMRU St Andrews.

The Invest-vs-Delay Decision for Tidal Energy Development

This study is gathering the insights of executives and senior managers in the tidal energy industry to understand the strategic decision-making regarding the timing of commercial-scale tidal energy investment. The study, funded by the Harrison McCain Foundation, can serve to inform government policy.

Tidal Energy School Outreach

ATEI, in partnership with TD Friends of the Environment Foundation and the Ivan Curry School of Engineering at Acadia University, has been developing a Tidal Energy School Outreach Program to bring tidal energy hands-on activities and information into Nova Scotian classrooms. In 2015, we reached over 300 students.



A student measures voltage from a 3D printed turbine blade configuration. The calculated power is plotted in real time and projected on a whiteboard.

Other Activities

- Ongoing tidal energy site and resource assessment and modeling at Digby region COMFIT sites (ecoENERGY funded project, p. 8)
- Use of fish tracking data to develop fish-turbine encounter models
- Participation in MRE standards development (TC 114)
- International tidal energy research and teaching with institutions in Iceland, US and UK
- Tidal energy presentations to professional societies, community groups and the NS Science Teacher's Conference

Meghan Swanburg
Acadia Tidal Energy Institute (tidalenergy@acadiau.ca)

Tidal Engineering Research at Dalhousie

Research on tidal engineering performed at Dr. Dominic Groulx's lab in Mechanical Engineering at Dalhousie University in 2015 saw the conclusion of two active research projects and the initiation of two more. Mr. Nicholas Osbourne completed his MASc in mechanical engineering by successfully defending his thesis and then presenting the results of his work, which was in part funded by OERA, at this year's EWTEC in Nantes, France. Nick's project, titled "*3D Modelling of a Tidal Turbine – A Numerical Investigation of Wake Phenomena*" developed a numerical methodology, using ANSYS CFX, to study turbulent flow around a tidal turbine and in the wake. Being the first project of this sort in Nova Scotia, it will serve as a springboard on which to launch advanced further numerical studies in tidal engineering.

Case in point, out of this work, two new projects are taking shape: in the summer of 2015, Grant Currie, a now third year mechanical engineering student at Dalhousie, applied Nick's methodology to the set of blades created by the Dalhousie-Strathclyde research collaboration. The numerical results, which have yet to be analysed will be compared to the experimental two tank results obtained by PhD candidate Robynne Murray using the Strathclyde tow tank test facility.

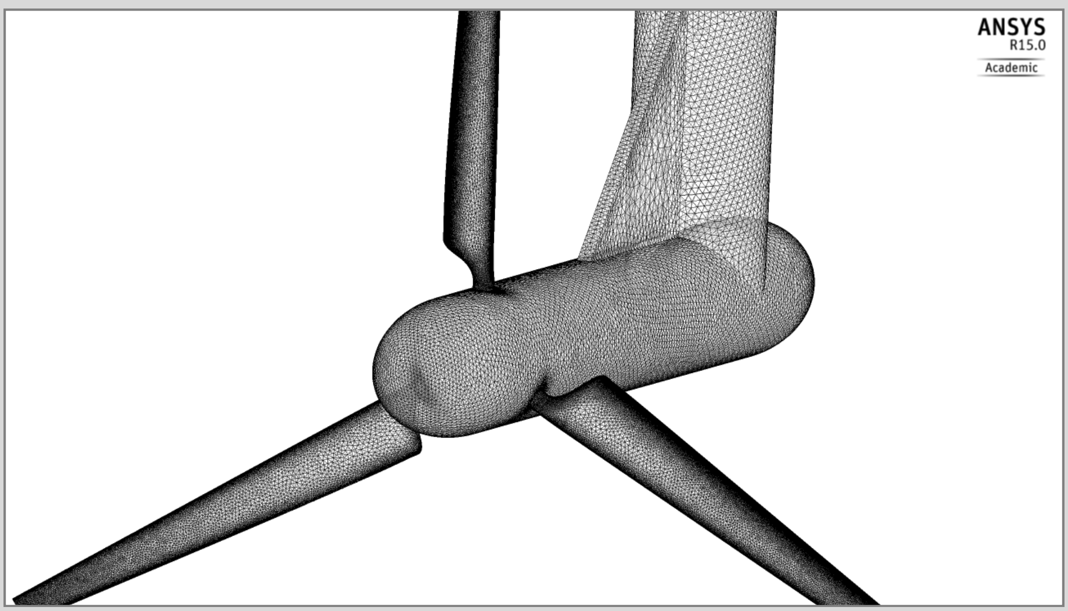
Another project, in collaboration with Alex Hay of Oceanography at Dalhousie University will push Nick's methodology by adding real tidal flow conditions to the fully transient simulation. This project will provide the engineering team at Dalhousie with a robust fully transient/turbulent numerical tool for flow analysis on turbines.

Finally, the other complete project was done in partnership with OpenHydro Canada, through an NSERC Engage grant. This six month project, also performed by Nick Osbourne, looked at the impact of subsea based geometries on the overall loading and performance of Open Hydro's turbine; using an actuator disk approach for the turbine. This project started with Nick (through an OERA travel grant) and Dominic spending some time at Open Hydro's R&D facility in Ireland in early January.

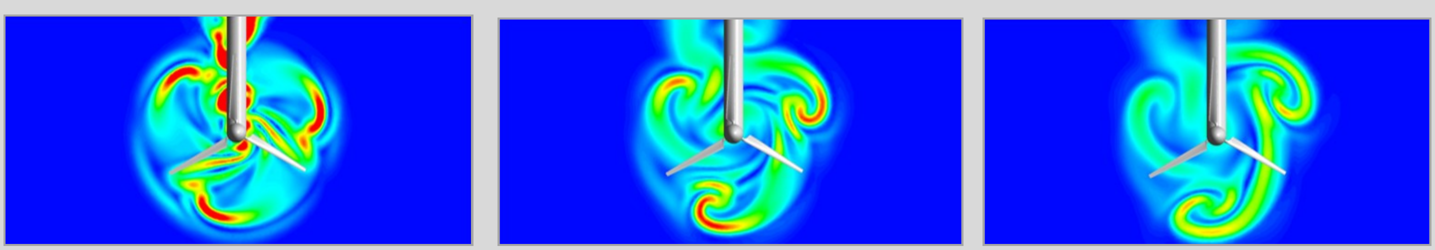
2015 provided a lot of momentum to the CFD research in tidal power performed in engineering at Dalhousie University, 2016 should be even more productive.

Dominic Groulx,
Department of Mechanical Engineering, Dalhousie University
(dominic.groulx@dal.ca)

Right: A detailed view of turbine mesh.

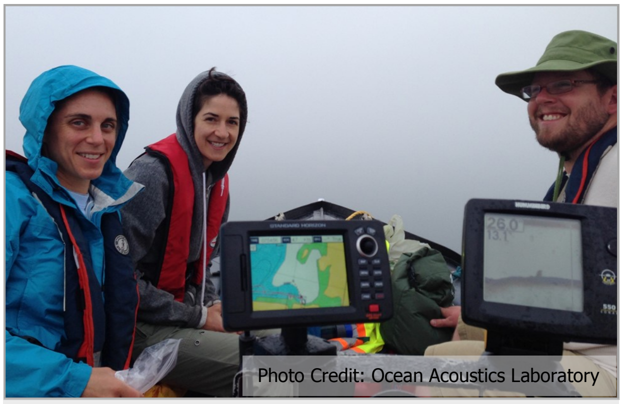


Below: Longitudinal slices of vorticity and at 1D, 3D, and 5D downstream, respectively, where D denotes the turbine diameter. Noticeable in each are three spiraling vortices at the edge of the rotating wake. These spirals essentially draw in and facilitate mixing of high and low velocity regions.



Dal Oceanographers Measure Noise, Turbulence and Waves

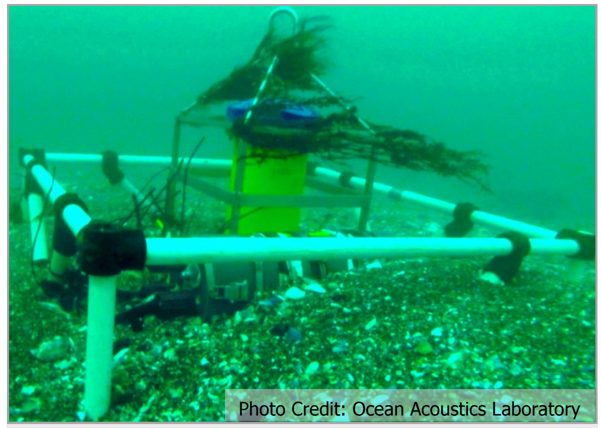
Over the past year, members of Dalhousie's Ocean Acoustics Laboratory have been busy characterizing the natural flow conditions at sites within both Grand Passage and Digby Gut which are being developed by Fundy Tidal Inc. Several measurement campaigns have been conducted and data analysis is ongoing with the aim of establishing baseline datasets in advance of turbine installation. Three major research projects are underway which focus on the accurate quantification of: (1) wave conditions, (2) turbulent fluctuations, and (3) ambient noise levels.



Rachel Horwitz, Anne Lombardi and Richard Cheel happily conducting hydrophone surveys on a typical foggy day in Grand Passage.

Colleen Wilson, an MSc student, is studying wave dynamics in Grand Passage using data from a cabled Acoustic Doppler Current Profiler (ADCP) and a spectral wave model (SWAN). Large amplitude waves – up to 3 m observed significant wave heights – are generated through wave-current interactions, especially during winter storms. By determining the conditions under which these waves develop, Colleen will be able to estimate their potential impact to the loading forces experienced by installed turbines.

Turbulence is also a characteristic of the highly energetic flow that has the potential to generate extreme loads and impart damage to a turbine. Assessments of the spatial structure and temporal variability in the turbulent fluctuations are being conducted by Rachel Horwitz (Post-Doc) and Justine McMillan (PhD student). The most recent measurement campaign was completed this past August in Digby Gut where the Stablemoor buoy was deployed for 10 days. Instrumentation onboard the buoy was used to obtain precise measurements of the flow at "hub height" – a feat that is difficult to achieve using standard instrumentation techniques. In that context, the Lab is also taking a lead role in the development and testing of the Vectron – a wide-baseline bistatic acoustic Doppler system – soon to be deployed by FORCE in Minas Passage on the FAST platform.



Cabled ADCP being used to make continuous current and wave measurements in Grand Passage.

The instrumented Stablemoor buoy was deployed in Digby Gut in August 2015 to obtain turbulence measurements at "hub height".

The quantification of baseline noise levels is being carried out by PhD student, Anne Lombardi. Several passive acoustic datasets have been collected in Grand Passage, with the aim of both identifying the noise generated from tidal turbine operation and optimizing the effectiveness of local marine mammal monitoring efforts. Field work conducted in summer/fall 2015 included drifting measurements of directional noise, bottom video (to address noise generated from mobile sediments), and a moored multi-channel hydrophone with local flow measurements.

All of this research is being carried out under the guidance of Dr. Alex Hay, with significant assistance from Research Associate Richard Cheel, and the help of many others both in the laboratory and in the field.

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Dynamic Systems Analysis

Over the past year Dynamic Systems Analysis Ltd. (DSA) has had the opportunity to work with a number of tidal energy organizations focused on projects in the Bay of Fundy. DSA provides progressive and accessible dynamic analysis software and expertise to enable those working with vessels, structures, lines and technologies in harsh marine environments to reduce risk.

What is dynamic analysis? In ocean engineering, dynamic analysis consists of testing numerical models of vessels and equipment operating in ocean conditions using time-domain simulation. Risk and uncertainty in vessel motions and loads on equipment are reduced by considering dynamic effects of ocean currents, wind and waves. Predictive engineering models like these are invaluable for areas like the Bay of Fundy where strong turbulent tidal flows and harsh winter storms present challenges for the tidal industry. ProteusDS, the in-house dynamic analysis software package developed by DSA is commonly used by tidal energy companies for mooring, platform, and installation analysis.

Using ProteusDS, our team has recently been working with Black Rock Tidal Power / Schottel Hydro to model their Triton platform which is currently being developed for deployment at the FORCE test area in Minas Passage. DSA has been examining the effect of turbulence on the structural loads expected on the platform, the stability of the platform, and the response of the structure to wind, wave and current conditions.

DSA also successfully completed a project with OpenHydro to assess deployment operations in the Bay of Fundy from the installation vessel Scotia Tide. DSA's ProteusDS software was utilized to get a 3D view of the operations and assess the system response to various towing configurations.

We've continued to work as part of the NRCan ecoEnergy Innovation Initiative project led by Acadia University project entitled "Reducing the cost of instream tidal energy generation through comprehensive site assessment". As part of this project DSA has developed a mooring and platform design for a site in Grand Passage that will be tested in the coming months. The platform and mooring will be used to validate DSA's mooring designs for tidal areas. The platform has been constructed and installation plans are underway.

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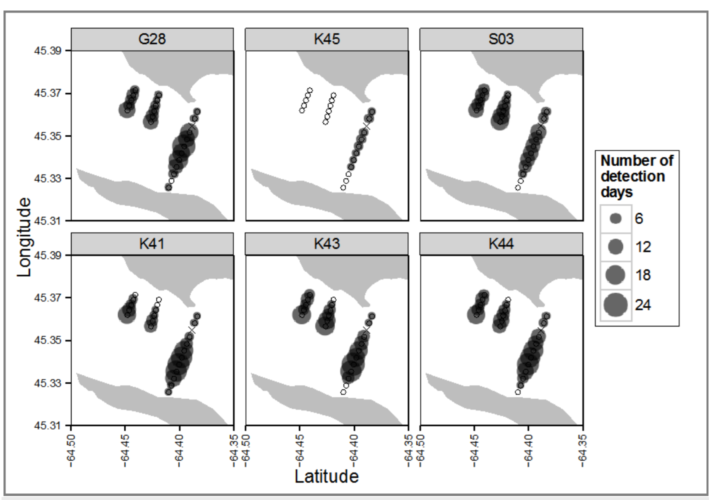
Overwintering of Striped Bass in Minas Passage

A collaborative multi-year study by Acadia University, and partners at the Ocean Tracking Network and the Department of Fisheries and Oceans, involved the tracking of migratory fishes in Minas Passage, including at/near FORCE, during 2010-2013. Vemco acoustic telemetry was used to identify temporal trends in presence, vertical distribution and movement patterns of selected fish species of concern.



Spatial distribution of Striped Bass detections (6 tagged fish) in Minas Passage during winter 2012-2013. (Keyser et al, 2016)

A surprising finding from Freya Keyser's MSc research project was the detection of tagged Striped Bass in Minas Passage throughout the winter of 2012-2013. During this season, cold temperature effects on extent of diel vertical migration were evident. If lethargic when in cold waters, Striped Bass presence at FORCE during the winter months (–1.5°C to 6°C) may put them at greater risk of direct interaction with operational turbines. We expect that risk during winter will depend on the water depths occupied by turbines and cold water effects on Striped Bass metabolic activity.

Acadia's acoustic telemetry research reports can be found at http://www.oera.ca/marine-mammals-fish/.

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An adult Striped Bass, Morone saxatilis

Turbine Array Impacts on Suspended Sediments in Minas Basin

Suspended sediments in Minas Basin in the upper Bay of Fundy, where significant changes in tidal processes could occur in the future due to tidal power extraction, are investigated in Ashall *et al.*, (2016) using basin-wide observations and a coupled three-dimensional hydrodynamic, wave and sediment model. Observations from an 8-day cruise on the CCGS Hudson in June, 2013, that include water levels, currents profiles, surface waves, particle sizes, sediment fluxes and suspended sediment concentration (SSC) profiles are used to validate the numerical model. The predicted SSC is spatially and temporally compared to observations the results indicate that the observed trends in major depositional features, erosional areas and the vertical profiles of SSC at different ship observation stations are generally well reproduced by the model.

To develop an understanding of changes in SSC in the Minas Basin due to tidal power extraction, two idealized model scenarios are used to simulate different sizes of tidal in-stream device farms. Arrays of turbine regions were modelled as semi-porous hydraulic structures acting over the bottom of the water column, to simulate low and high power extraction cases. In the high power extraction case, far-field intertidal areas in Cobequid Bay are the most affected with a notable decrease in mean SSC, while very small changes occur at other stations as indicated in the figure below.

Overall, the change in averaged SSC at observation stations indicates that the implementation a large-scale tidal power extraction array causes a significant decrease in SSC which could affect physical and biological processes particularly on the fine-grained intertidal areas around the macrotidal basin.

The idealized tidal power extraction scenarios that are numerically implemented in this study are used to quantify the impacts of turbines on currents and suspended sediment concentrations, and the results emphasize the sensitivity of the system to changes in flow caused by a large-scale tidal energy farm. This work provides a foundation for research into the potential changes to the Minas Basin and the greater Bay of Fundy and could lead to lower tidal power impacts on the marine environment.

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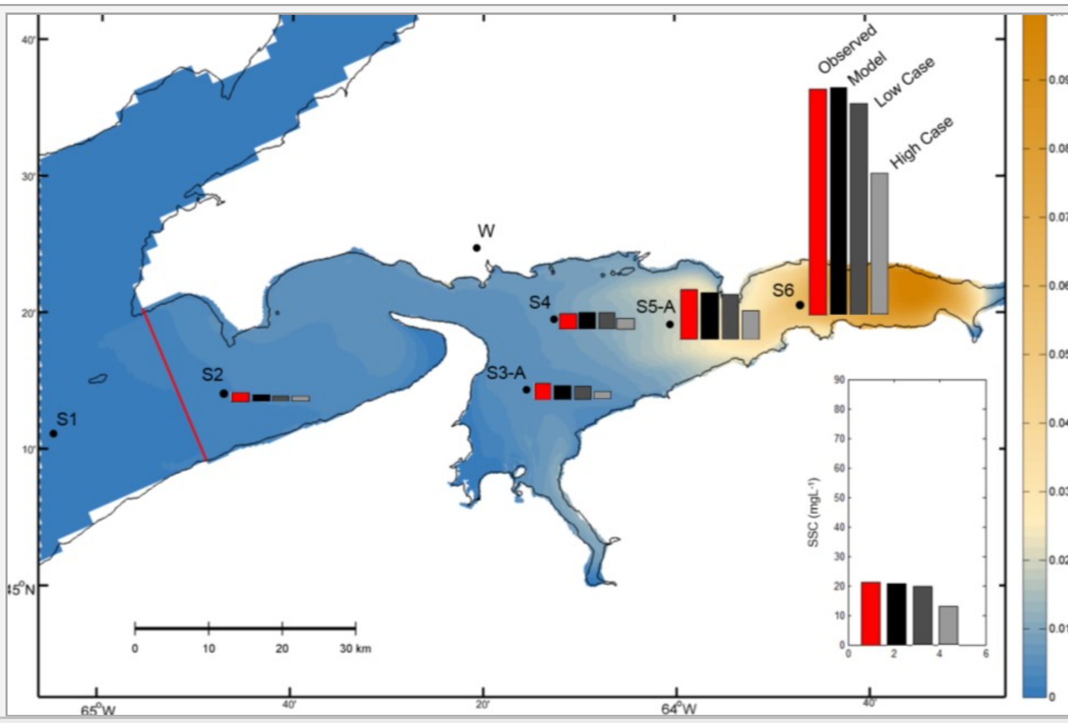
Reference

Ashall, L.M., Mulligan, R.P., and Law, B., 2016. Variability in suspended sediment concentration in the Minas Basin, Bay of Fundy, and implications for changes due to tidal power extraction, *Coastal Engineering*, 107, 102-115. doi:10.1016/j.coastaleng.2015.10.003.



Map of predicted time- and depth-averaged fine suspended sediment concentrations (mgL-1) with bar plots indicating the observed (red) and predicted (black = no turbines; dark grey = low power extraction case; light grey = high power extraction case) time- and depth-averaged SSC at 5 sites (S2-S6) over the period of June 6-13, 2013. Legend indicates the time-, vertically-, and horizontally averaged values over all 5 sites.

Cape Sharp Tidal Making Headway

Cape Sharp Tidal launches the Scotia Tide deployment barge, the largest heavy lift capacity barge in Atlantic Canada, purpose-built for deployment and recovery operations.

The Cape Sharp Tidal team has recently completed two major operations in preparation to deploy a 4MW tidal array in the Bay of Fundy in 2016 - the installation of its Y-shaped connector cable at the FORCE site—a world first—and the launch of the Scotia Tide deployment barge in Pictou.

The connector cable is an interconnection hub that will fasten the turbines to the existing 16MW subsea FORCE export cable. Not only was the operation executed safely, but it's especially exciting because it's the first project component to be deployed, and the only system of its kind in the world. Cape Sharp Tidal also deployed 300 metres of cable to our berth site at FORCE.

The operations barge, christened the Scotia Tide, took her maiden test voyage around the Pictou Harbour. The unique, catamaran-style vessel is the largest heavy lift capacity barge in Atlantic Canada. The 64 metres long, 37-wide, 650-tonne barge has a 1,150-tonne carrying capacity. Purpose-built for deployment and recovery operations, it's equipped with three heavy-lift winches that give it a unique capacity to lower and raise turbines from the sea floor.

Turbine assembly is also advancing, with the blades installed in Turbine #1 and the rotor and stator assembly work is complete.

Cape Sharp Tidal Installs Subsea Connector Cable

These operations are significant milestones in Cape Sharp Tidal's plan to install two 2-megawatt in-stream tidal turbines in the Bay of Fundy. And every success related to manufacturing and operations is an important step toward building a tidal energy sector in Nova Scotia.

Cape Sharp Tidal is a joint venture between Emera and Open Hydro, a DCNS company.

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Upcoming Tidal Energy Events

Marine Energy Technology Symposium (METS 2016)
Washington, DC. April 25-27, 2016.
http://www.nationalhydroconference.com/index.html

Nova Scotia Energy R&D Forum 2016
Antigonish, Nova Scotia. May 25-26, 2016.
http://www.oera.ca/meetingsevents/nova-scotia-energy-rd-conference-2016

11th BoFEP Bay of Fundy Science Workshop
Fredericton, NB. June 8-10, 2016.
http://www.bofep.org/wpbofep/?page_id=18

International Conference on Ocean, Offshore & Arctic Engineering (OMAE)
Busan, South Korea June 19-24, 2016.
https://www.asme.org/events/omae

International Conference on Offshore Renewable Energy (CORE 2016)
Glasgow, UK. Sept 12-14, 2016.
http://asranet.co.uk/Conferences/OffshoreRenewableEnergy

Asian Wave and Tidal Energy Conference Series (AWTEC) 2016
Marine Bay Sands, Singapore. Oct 24-28, 2016.
http://www.awtec.asia/awtec-2016/

About FERN

FERN is an independent non-profit organization initiated by academic and government researchers as a forum to coordinate and foster research collaboration, capacity building and information exchange to understand the environmental, engineering & socio-economic implications of tidal energy development in the Bay of Fundy.

BECOME A MEMBER

FERN membership is FREE and open to all involved or interested in tidal energy-related research, including universities & colleges, government agencies, environmental NGOs, consultants, and the private sector.

To become a member, please visit our website, http://fern.acadiau.ca

FERN
FUNDY ENERGY RESEARCH NETWORK

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Acknowledgments

Special thanks to our members and partners, and everyone who provided articles, images, information and edits for this issue of the FERN newsletter. The many ongoing contributions of the FERN Committee co-Chairs and members, and our sponsors (logos below), are greatly appreciated.

This newsletter was designed and edited by Meghan Swanburg and Anna Redden.

We welcome your feedback on this issue and any suggestions for future issues of FERN's annual newsletter.

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