OERA Offshore Energy Research Association

ANNUAL REPORT 2015-2016

Research That Works

Table of Contents

The Offshore Energy Research Association of Nova Scotia (OERA) is an independent, not-for-profit contract research organization with a mission to lead offshore environmental, tidal and petroleum energy research for Nova Scotia's offshore energy sectors. The OERA's scientific research initiatives are structured as collaborative, multi-stakeholder programs and are intended to contribute to risk reduction and support investment decisions.

OERA's role as a research facilitator is vital to ensuring that Nova Scotia's offshore energy sectors are developed in a responsible and sustainable manner. Through strategic partnerships with industry, government and academia and a global network of researchers, OERA leads research initiatives targeted at resolving critical knowledge gaps in marine related environmental, tidal and petroleum issues.

The OERA is supported by the Province of Nova Scotia through the Department of Energy. To date the OERA, in collaboration with other government, industry and academic partners has invested over $32 million in offshore related research projects. Research investment in marine geosciences has contributed to a $2.1 billion petroleum exploration commitment in offshore Nova Scotia. Further, millions expended in tidal research has given the province the confidence to commit to developing 300 MW of tidal power that is expected to bring $1.7 billion in GDP and 22,000 jobs to Nova Scotia by 2040.

We gratefully acknowledge the important contribution made by all OERA stakeholders and partners.

Minister's Message

Nova Scotia
Minister of Energy
Michel Samson

Research is at the core of any effective energy policy. Sound research enables us to create the right conditions for industry growth, job creation, all while protecting Nova Scotia's ocean environment.

To support the mandate of the OERA, the Nova Scotia government has invested more than $32 million dollars over the past 10 years to better understand tidal energy in the Bay of Fundy. With grants from the OERA, researchers from our universities and colleges are innovating and finding solutions to challenges as we look to harness the power of the highest tides in the world. We have a unique opportunity to lead the world in the development of this new, clean energy sector.

The OERA has also been a key resource for creating a better understanding of Nova Scotia's offshore petroleum resources. Building on the highly successful Play Fairway Analysis (PFA) and its proven track record of attracting offshore exploration in the oil and gas sector, OERA continues to fund and coordinate critical research to expand our knowledge of our offshore energy potential. This is contributing to record expenditure commitments by some of the largest and most successful energy companies in the world, all focused on discovering the vast energy resources in our offshore. I would like to extend my thanks to the dedicated OERA team.

OERA Chair
Dale Keefe

Chair's Report

As you read the information contained in the pages of this annual report, I am confident that you will agree with me in concluding that the OERA model, approach and team are delivering real results and making a strong contribution to our collective understanding of Nova Scotia's tremendous offshore energy resources.

With the participation of Nova Scotia's five research intensive universities and the province's network of community colleges, we are demonstrating the expertise necessary to assess, protect and develop offshore energy assets right here in our own back yard. Most OERA-led projects include academic researchers from our province working with colleagues from around the globe connected to OERA's research network. This is all to achieve the best possible solutions to critical scientific questions related to the marine energy sector in Nova Scotia.

Disciplined scientific research enables good decision making. That is a critical role that the OERA plays to support its primary stakeholder – the provincial Department of Energy, as it provides an effective framework for the assessment, management and protection of Nova Scotia's energy resources in the offshore.

In my role as a board member and chair, I look forward to continuing the work to better understand our offshore energy resources under the unique OERA model. The past 10 years have been very productive but there still remains much more important research to do.

Director's Report

"Each of these science based initiatives has the potential to transform both the energy future of our province and the economic conditions for generations to come"

OERA Executve Director
Stephen Dempsey

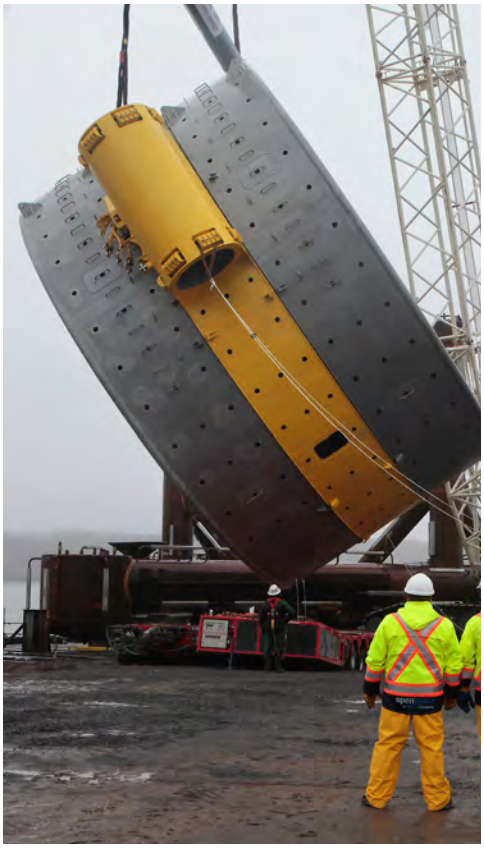
A Message from OERA Executive Director Stephen Dempsey

Looking back over the last 10 years since the OERA was established and recognizing the vast amount of research projects completed by the association and its partners, I am pleased to report that we have been making consistent and measurable progress toward our objectives of understanding the impacts for deployment of commercial scale in-stream tidal energy devices in the Bay of Fundy and furthering the analysis of the geological and petroleum systems in Nova Scotia's offshore to complete the Play Fairway Analysis (PFA).

Each of these science-based initiatives has the potential to transform both the energy future of our province and the economic conditions for generations to come. For example, Shell, BP, Statoil and their partners have committed to spend in excess of $2.1 billion dollars to explore for petroleum resources which have been measured under the PFA at 8 billion barrels of oil and 120 trillion cubic feet of gas. In the Bay of Fundy, OERA has forecasted that as the number of tidal turbine deployments grow over the next 25 years, our province stands to realize some $1.7 billion in GDP impacts, create almost 22 thousand full time jobs, and reduce our carbon footprint by approximately 25 million metric tonnes.

Even with all of the knowledge we have gained through the number of individual research projects completed, representing an investment of over $32 million, more work can be done to encourage investment while ensuring the environment is protected. With continued financial support from the provincial Department of Energy, active participation from our academic partners, and engagement with key industry players in the offshore energy sector, OERA will continue its leadership role in collaborative research that advances our understanding of our offshore energy resources, improves sustainability, and ultimately attracts investment for the benefit of all Nova Scotians.

Tidal Research Collaborators



Nick Osbourne

Having Impact in Tidal

ENGINEERING A TIDAL ENERGY FUTURE

Nick Osbourne's career is on an upward trajectory in the tidal energy industry. The 27 year old mechanical engineer is quick to acknowledge that working in tidal energy is not just a career choice, but something more.

"I've spent years directing myself towards tidal energy and I'm quite passionate about it," he says.

Nick is on the cutting edge of tidal energy research and its application in Nova Scotia, and the OERA has been supporting this fast rising star from the very start.

Currently, Nick is the new Integration Manager at Black Rock Tidal Power Inc., a Canadian company based in Halifax and owned by SCHOTTEL HYDRO—a German based tidal energy technology developer.

Nick is overseeing the design of the gravity base that will keep the unique turbines, all 40 of them, linked together in an array, securely attached to the Bay of Fundy seabed. It is anticipated the turbine array will produce 2.5 MW of power once installed.

However, the challenges are coming fast, as is the deadline for installation in the summer of 2017.

Nick explains that the Minas Passage in the Bay of Fundy is a formidable place to work in, not only because it has the highest tides in the world, but also, the tidal flow in the Passage is extremely fast.

Black Rock Tidal Power's turbines are designed to operate at the top of the water column, within that fast flow, maximizing energy potential and creating a lot of thrust. The power of the thrust means the gravity base is critical to

keeping the array anchored to the seabed.

"The challenge for me is to come up with a feasible and cost effective way to build this gravity base, ideally here in Nova Scotia. Build it, move it to site, and deploy all within these pretty extreme constraints," says Nick.

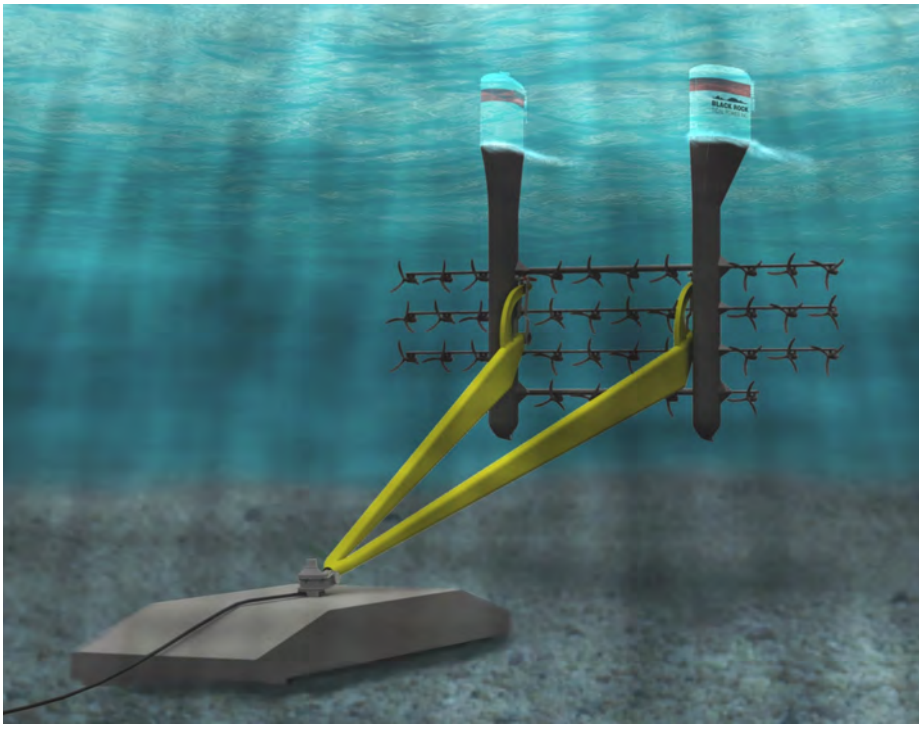
Before joining Black Rock Tidal Power, Nick received multiple funding opportunities provided by the OERA. The first of these opportunities came while working with Dr. Dominic Groulx, an Associate Professor in the Mechanical Engineering Department at Dalhousie University.

"His interest and enthusiasm in the tidal energy field is one of the main reasons Nick was the perfect candidate for our first research foray in tidal power," says Dominic, "Nick had worked with me on previous projects while an undergrad, and I knew he would bring the same dedication and engineering mind to a Master of Science project."

Early on in his Master of Science research, Nick participated in the OERA Student Research Travel Program, where he travelled to the University of Tasmania in Australia to study a numerical modeling approach called computational fluid dynamics (CFD) and learn how to run the associated software.

On his return he fine-tuned his research and received another round of funding this time for his Master of Science project.

Nick's Master of Science project, supervised by Dr. Groulx, focused on numerical modeling, using powerful software to quantify the interaction of fluid flow around a single turbine, which could consequently lead to determining what the interaction would mean for the subsequent turbines in the array. The model would ultimately help inform how to layout turbine arrays for peak performance.

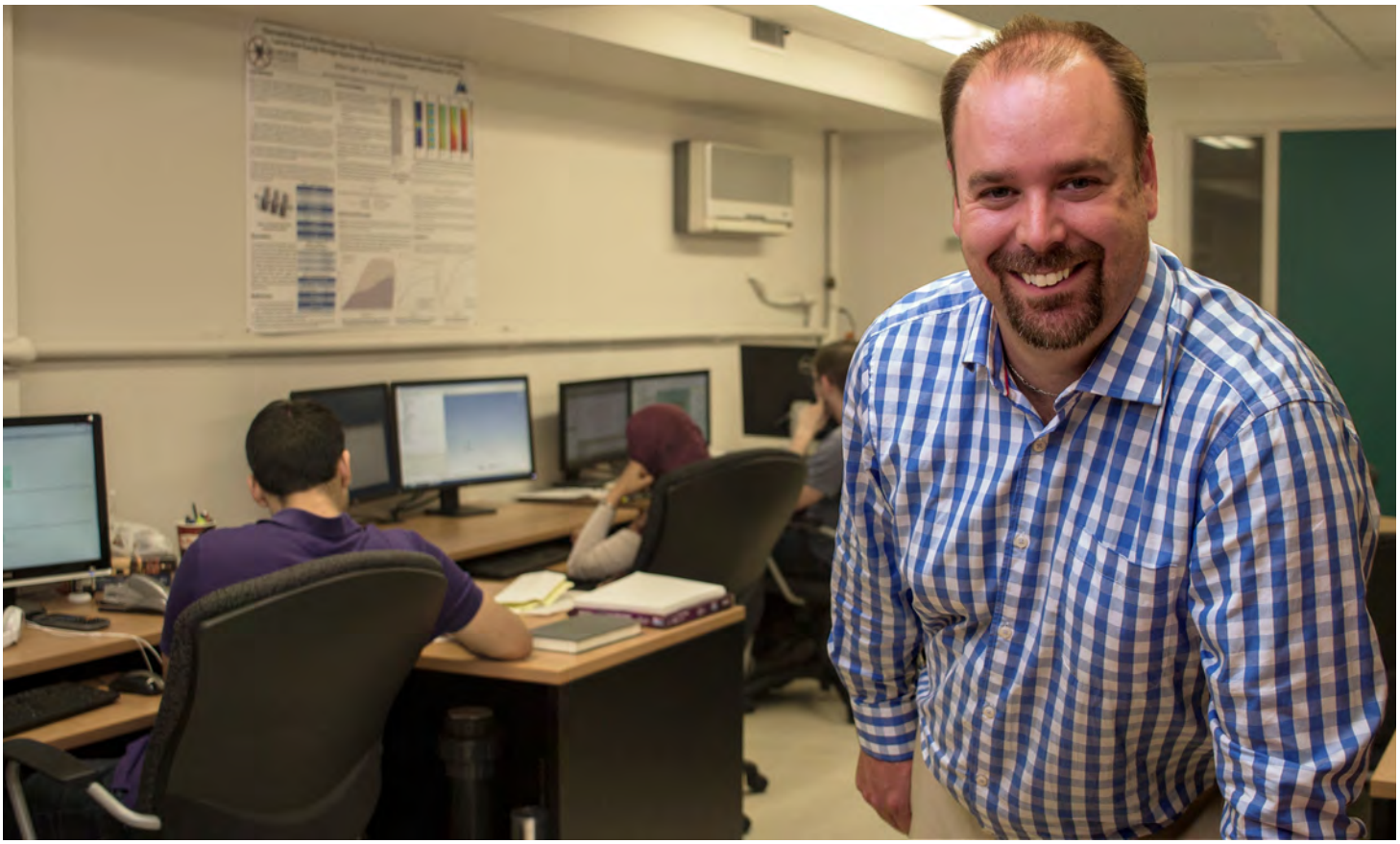


The project was funded in part by the OERA Open Call program that Nick applied for after he had returned from his training in Australia.

"The student grants from OERA have definitely been integral to my research career at Dalhousie. Getting the opportunity right off the bat at the beginning of my master's to work with experts and researchers . . . in Australia really drove the direction of my research…and then the grant proposal that OERA approved, it made the whole project possible," remarks Nick.

Today, Nick sees a bright future for tidal energy in Nova Scotia.

"There is a lot of positive thinking from the public, and from government, and our universities and colleges. I definitely foresee tidal as part of our long run energy future here in Nova Scotia," he says.



Dominic Groulx

Creating Opportunities in Tidal

MENTORING TIDAL RESEARCHERS

Despite the breadth of research in tidal energy Dr. Dominic Groulx oversees, his own research background is actually not in tidal.

An Associate Professor in Mechanical Engineering at Dalhousie University, Dominic founded and runs the Laboratory of Applied Multi-phase Thermal Engineering. The lab's research output focuses mainly on heat transfer problems, and centers on Dominic's primary field of expertise.

In 2011, the Nova Scotia government approached the engineering faculty at Dalhousie to encourage engineers to get involved in the tidal energy field. Dominic saw this as an opportunity to use his expertise and lab infrastructure to apply this novel field to address evident scientific novel challenges.

"We had the tools, we had the computers, we had the software and the knowledge to get going in simulating fluid flows over turbines. That's how my specific lab got involved on the tidal side," Dominic recounts.

Dominic's early forays into the tidal energy field began by recruiting Master of Science student Nick Osbourne. Together they began exploring the important research questions in the tidal energy literature. They became intrigued by the issue of how the wake caused by one turbine could effect subsequent downstream turbines.

Dominic and Nick decided to use the lab's strength in numerical modeling and computational fluid dynamics to create a simulation that

could quantify the fluid flow through and behind a turbine (See Nick Osbourne's Profile). Dominic and Nick submitted the project to the OERA with the goal of securing a grant under the Open Call program.

He believes they were successful in securing the grant because of the obvious fit with the organization's mandate to support the tidal industry in figuring out how to optimize turbine performance.

“We gave a good research objective; we were looking at flow over turbines and the impact of the wake. One of the important issues OERA was looking at was that eventually, we'll put massive turbine arrays underwater and you need to know how they're going to interact together.”

Since his early research work into tidal energy, Dominic has been an enthusiastic supporter for its continuation within his department and lab. He believes that the future of tidal energy research is highly relevant to the kind of engineering know-how that he is developing in his PhD and Master students.

With initial turbine installations planned this year in the Bay of Fundy, and more to follow over the next few years, the research challenges around placing and keeping turbines in the water are, Dominic argues, primarily engineering ones.

"Placing a turbine underwater is a very complicated problem," he says. "We see wind turbines go up every other day, and wind is pretty easy. Air isn't a dense fluid, it doesn't impart a ton of force upon a structure. Water is a thousand times denser,"he says.

Dominic is currently wrapping up another OERA supported project that used CFD modeling simulations with turbulent flow data from the Bay of Fundy, something Dominic sees as the next step in extrapolating how turbulence might impact on turbine performance.

"We're slowly moving towards using more relevant data, so we're getting results that are closer and closer to reality," he comments.

Dominic often tells companies that while solving engineering problems in tidal research is the focus, they should not lose sight of the longer term benefit of graduating students that have worked to resolve these problems.

"Now we are graduating students who are tidal researchers. Those will be the researchers who drive the field for the next 40 years. Those are the people we want driving that field, because they picked it, they wanted to do it, they've been studying for years and years. . . and it's really their field of study," he says.

Dominic's enthusiasm for taking up the challenge of tidal energy research, his willingness to form academic and research collaborations across borders, and his mentoring and training of the next generation in this cutting edge field makes him an important collaborator with the OERA.

Anna Redden
Having Impact in Tidal

PROTECTING THE MARINE ENVIRONMENT

Dr. Anna Redden comes to Kingsport Beach, which overlooks the Minas Basin on the Bay of Fundy, when she is in need of a spiritual lift. It is a place with which she feels a deep connection.

Anna and the Bay have a lifelong relationship that started in her childhood, and is now present in her work as a professor and marine ecologist at Acadia University.

"I have a passion for this water body. I grew up in Windsor on the Avon River, and I used to play in the mudflats as a kid…then I studied at Acadia. A lot of my early research experience is right here in this Minas Basin. So I guess I feel very rooted here, and I feel a sense of responsibility."

Anna's sense of responsibility is a motivator in her current research, which monitors the potential impact of tidal energy development on the marine environment— particularly its impact on fish and marine mammals.

As the Director of both the Fundy Energy Research Network (FERN) and the Acadia Tidal Energy Institute (ATEI), she has been a leader in building a strong tidal energy research community in the province. One that, according to Anna, is doing work which is having an impact on the tidal sector both at home and abroad.

"We're actually contributing to the global understanding of how to do this successfully, and the environmental effects monitoring programs, and associated research is a part of that," she says.

Now, with the first two tidal turbines ready for deployment at the Fundy Ocean Research Center for Energy (FORCE)

testing facility, and more expected to follow, Anna sees a whole new set of challenges and opportunities arising.

"When more devices go into the water it will become more complex, because we will potentially have cumulative effects of multiple turbines, so that's going to require some clever research projects," she says.

Anna is contributing to a number of OERA-supported research projects focused on developing and then using state-of-the-art technologies to monitor fish and marine mammal presence and activity around the turbines.

It is only by understanding how marine life interacts with the turbines, Anna explains, that the impact of encounters can be assessed, and if necessary, mitigated.

One of Anna's research contributions, along with Acadia University, is to the OERA-funded Integrated Systems Environmental Monitoring (ISEM) project led by Emera Inc.

The project involves Nova Scotia's Ocean Sonics icListen Smart hydrophones (underwater microphones), and UK based Tritech's Gemini multi-beam imaging sonar, to provide integrated real time data to identify marine life and their movements in the fast moving currents around the turbines.

The integrated technologies will be attached as multiple sensors to the two soon to be deployed Cape Sharp Tidal turbines.

"I think that using these culmination of sensors and collecting data 24-7 is going to be very powerful for us in trying to understand what is going on in and around the turbines," she says.

For Anna, collaborating with the OERA is a natural fit. She says the organization is not only pivotal in getting her research funded, but they are also taking on a leadership role on issues where others might not.

"I think one of the special things about the OERA is that they decided early on they were going to prioritize in certain areas, and one of those areas is environmental research. They took on the responsibility of saying this falls within our wheelhouse, and they've maintained it for a long period of time," she explains.

Anna will continue to collaborate with the OERA as tidal energy development progresses. She says tidal energy is important as a clean renewable energy source for future generations.

"I think we need to keep going on this path. We have climate change issues and we have declining fossil fuel. We need to start thinking about the next generation, and what their energy needs are going to be and where they're going to get that energy from," she says.

Nick Fyffe

Having Impact in Tidal

THE POWER OF DEPLOYMENT

Marine engineer Nick Fyffe thrives on the challenges of working in the tidal energy industry—an industry that is at an embryonic stage where novel thinking and problem solving is critical.

"It's exciting to be part of something innovative and cutting edge. It's an opportunity that doesn't come up very often," he says.

As the Site Development and Project Manager of Cape Sharp Tidal (a joint venture of Nova Scotia's Emera Inc. and Ireland-based OpenHydro) he is in charge of numerous research and development projects.

One of his projects is overseeing the deployment and installation of two in-stream tidal turbines in the Bay of Fundy's Minas Passage. Each turbine is 16 meters in diameter and weighs a thousand metric tonnes—including its gravity base that sits on the seabed, anchored by its own weight.

It is the flow of water that turns the turbines blades to generate electricity, and at five meters a second the Bay of Fundy boasts some of the fastest flowing water anywhere in the world. With the help of the Bay's currents, these two turbines are expected to generate 4 MW of energy into the Nova Scotia power grid, and lower CO_2 in the province by 6,000 metric tonnes per year.

Nick points out that researchers estimate up to 3,000 MW of energy can be sustainably extracted from the upper Bay of Fundy. That is enough to power 1.5 million homes - more than all the homes in the province.

Nick says that with the

uniqueness of the Bay and the provision of a state-of-the-art tidal research and testing center, the Fundy Ocean Research Center for Energy or FORCE, tidal developers from around the world are coming to Nova Scotia to test their technology.

However, Nick cautions that while the Bay is an ideal environment for energy extraction, due to the environmental conditions of the Atlantic Ocean, it's also one of the most demanding.

"It's a huge resource, but it's also one of the most challenging. If tidal energy developers can demonstrate their technology in the Bay of Fundy, then theoretically they can use their technology anywhere in the world," he says.

Deployment is an essential next step in tidal energy research, Nick says.

"The vast majority of research that's been carried out so far in the Bay of Fundy has been without any turbines installed in the water. The demonstration project we're doing at the moment will help to answer some of the questions that can only be answered by putting the technologies in the water and demonstrating them" he says.

Emera, one of Cape Sharp Tidal's partners, is already forging a path in tidal research with the help of the OERA and Innovate UK.

Nick is managing the research teams from companies in both the UK and Canada for the Integrated System for Environmental Monitoring (ISEM) project. The project will enhance and mount underwater sensor technologies consisting of hydrophones (underwater microphones) and sonar on the Cape Sharp Tidal turbines.

The goal is to provide integrated real time data showing how fish and marine mammals interact with the turbines.

"So with the data we get from these instruments, we're hoping to identify and analyze the behavior of marine mammals and fish around the turbine. So how do they behave as they approach the turbine? Do they move around it? Do they swim away?" Nick asks.

International research, as well as Cape Sharp Tidal's own pre-deployment environmental research, indicates that the turbines won't interfere with the marine environment. However, Nick says it's still early days for assessing effects, and this project allows for the testing that is essential to ensure that the unique marine ecosystem in the Bay is protected.

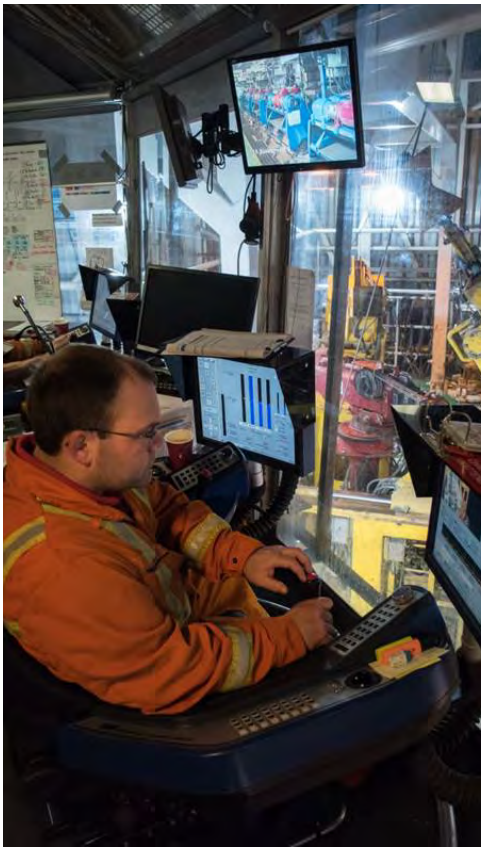
For Nick, as a manager at the forefront of tidal development, the OERA is an integral partner and a key player in the continuing research that will lead to the sector's success.

“The OERA have really been a fundamental part of our projects so far,” he says, “and they will continue to be, as we try to address the questions that we need to address moving through to the next phase of tidal energy.” he says.

Nick believes there couldn't be a more exciting time to be involved in tidal energy in Noval Scotia.

"For 100 years people have been trying to harness the tides here, and nobody was able to do it, but we're on the cusp now," he says.

Petroleum Research Collaborators




TREBAUD E-74

Chris Sangster

Creating Opportunities in Petroleum

MODELING THE SCOTIAN BASIN

Chris Sangster is starting in the Master of Applied Sciences in Geology program at Saint Mary's University with a trip to France. He is getting hands on training on a cutting edge 4D geoscience software modelling program called Dionisos Flow™. It's a once-in-a-lifetime opportunity to train with world renowned geoscientists at Beicip-Franlab in the French city of Rueil-Malmaison. After two months of training, Chris will return to Nova Scotia with an enhanced understanding of this proprietary sedimentary basin modeling software to use in his current research.

Chris, a participant in the OERA Student Research Travel Program, grew up in Halifax and developed an early fascination for rocks. The weekend trips he took with his father to explore nearby beaches and examine the stones strewn along the shoreline helped spark a passion in geological sciences that's still evident today.

Recognized early in his undergraduate studies as a researcher and future scientist to watch, he was awarded a Pengrowth-Nova Scotia Energy Scholarship, and began working with his current mentor and advisor Dr. Georgia Pe-Piper.

"I've always enjoyed every aspect of geology and sedimentology. I started to talk to Georgia about working on this thesis and things started coming together," says Chris.

His Master project will create a provenance model of the sedimentary sequence in the Lower Cretaceous to Upper Jurassic period, ultimately providing an understanding of what the sandstone intervals within the Scotian Basin looked like almost 140 million years ago.

Chris believes the model could provide insight regarding potential oil and gas reservoir quality in the area near Sable Island in the Scotian Basin.

“It should make it easier to de-risk exploration,” explains Chris, “and it should make it easier to pick out potential reservoir sandstones and potential intervals that will be new areas of interest that could be looked at.”

Chris’s two month trip to France will help give him the requisite skills to begin the modeling process. When his initial model is complete, Chris plans to return to Beicep-Franlab for four months to make any needed adjustments and produce his final model.

This type of international collaboration is made possible by OERA’s Student Research Travel Program, which gives young researchers like Chris the financial backing they need to make such trips.

“Without the OERA travel grant,” Chris says, “I would have had a very difficult time getting out there.”

Chris is keen to see his relationship with the OERA continue to develop in the future along with his career in the energy field, and he wants that to happen here, in Nova Scotia.

“I would love to be able to stay and keep working in the oil and gas sector in Nova Scotia. This research could be great because there’s so much of the Scotian Margin that still needs to be explored."

For Chris the best thing that could happen for the industry would be a big oil or gas find. He believes research like his will help the province attract exploration companies and invest in drilling and sampling programs.

"Large scale studies like this one, and others that have been done along the same lines, are important to get us to the point where we can make that kind of discovery," he says.

Helen Lau

Creating Opportunities in Petroleum

INVESTIGATING BELOW THE SURFACE

Dr. Helen Lau is working on an OERA funded research project that is undertaking a detailed data analysis of two ocean bottom seismometer profiles from the northeastern part of the Scotian Margin. The aim of the research is to help de-risk petroleum exploration efforts in offshore Nova Scotia by focusing on the regional geological history and evolution of the continental margin. The results will ultimately provide detailed information regarding the location and geometry of deep hydrocarbon source rock basins, the underlying continental crust and the uppermost mantle, all of which are critical for understanding the early tectonic rifting history of the northern Nova Scotia margin.

"Right now the industry is doing exploration with very little knowledge of what the tectonic history of the Nova Scotia Margin is. If we can provide a better understanding of tectonic development that

would really help them," she says.

The research project is regarded as a high priority for the OERA, and it aligns with one of the Association's core geoscience research objectives. It also complements the highly successful 2011 Play Fairway Analysis (PFA).

The PFA - a geoscience effort to provide a better understanding of the petroleum geology of the Scotian Margin - led to a geological re-interpretation of many features within the Margin.

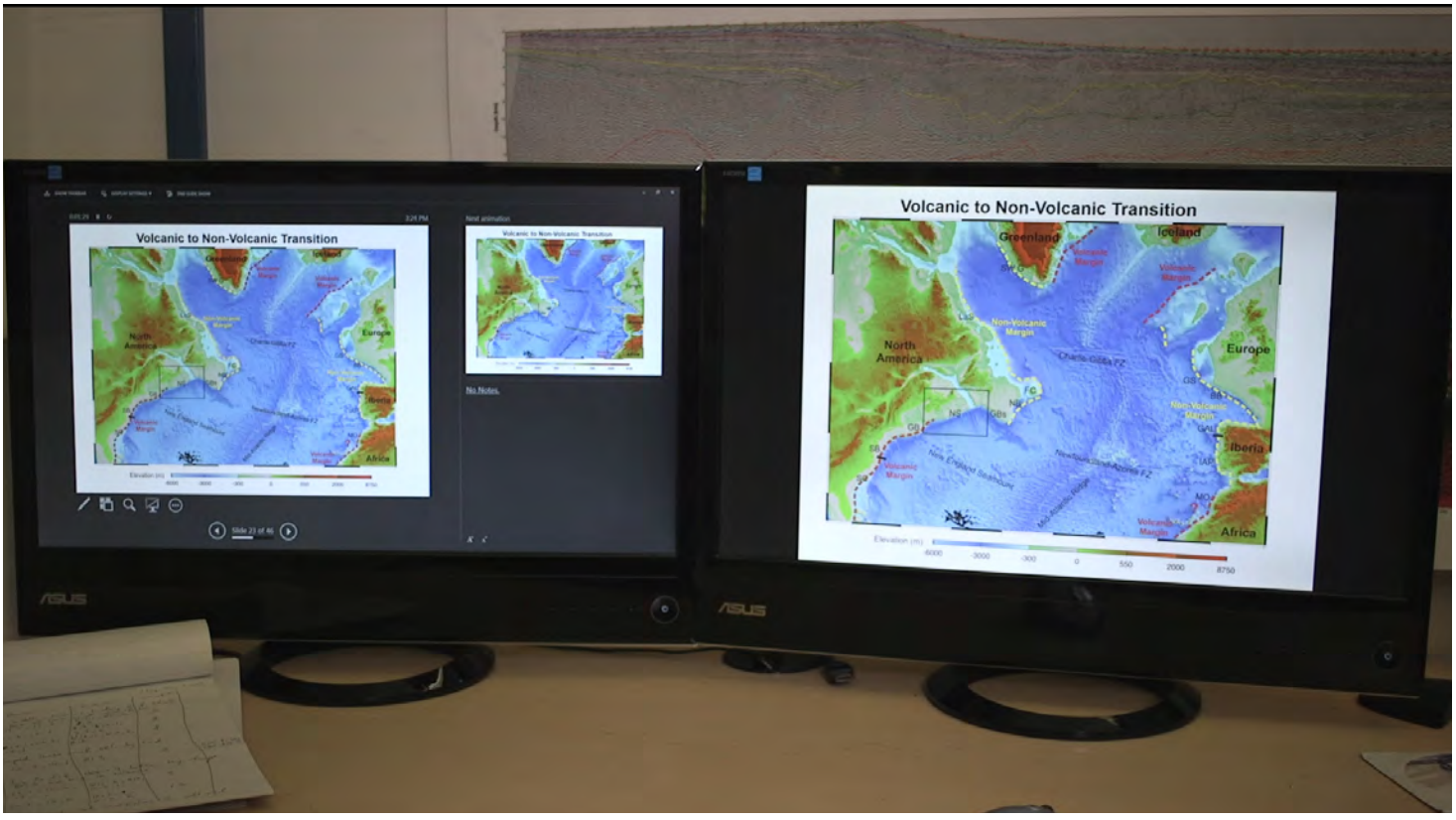
The general consensus to date among academic researchers is that the transition from volcanic to non-volcanic rifting occurs offshore south-central Nova Scotia.

This view is consistent with the absence of any direct evidence for a magma-rich margin.

But geological data compiled during the PFA suggest that magma-rich conditions, traditionally viewed as confined along Nova Scotia's southeast margin, could extend as far north as the Newfoundland-Azores transform fault.

This would mean the whole of Nova Scotia's offshore Margin could be magma-rich, which has significant implications for sedimentation patterns and the deposition of oil-prone source rocks.

For Helen, the OERA's funding support is critical for projects like hers, which she says provides peer reviewed academic research that the petroleum industry can rely on.



The Play Fairway Analysis

A Turning Point for Petroleum Exploration in Nova Scotia

The success story of the Play Fairway Analysis (PFA), Nova Scotia's ambitious geoscience research initiative aimed at rekindling offshore petroleum exploration, is also the success story of the OERA.

The PFA was born out of a difficult period in the history of petroleum exploration in the province.

The province saw a steady decline in offshore exploration licenses from a high of 50 in 2002 to an an all-time low of just 10 in 2009.

Petroleum companies paid multi-million dollar forfeiture fees to leave the province despite the Canada-Nova Scotia Offshore Petroleum Board's estimates of 12 to 39 trillion cubic feet of natural gas and between 1.3 and 4.5 billion barrels of oil reserves in the Scotian Margin.

With the potential for significant discoveries, why did companies leave? The Nova Scotia Department of Energy (DOE) commissioned studies that concluded the complexity of the petroleum geology in the Scotian Margin, along with the environmental conditions of the Atlantic Ocean, created more challenges here than elsewhere in the world.

The DOE responded by allocating $18 million from the forfeited fees to the OERA to complete the Play Fairway Analysis – a scientific undertaking to increase geological knowledge of the Scotian Margin in relation to its petroleum potential. Increased knowledge, they believed, would help attract exploration back to the region and rekindle interest in investment. Since 2011, the PFA has attracted more than $2.1 Billion in new exploration commitments which demonstrates the success of this initiative.

Andrew MacRae

Creating Opportunities in Petroleum

EXPLORING MICROFOSSILS

Dr. Andrew MacRae, Assistant Professor in the Geology Department of Saint Mary's University, was a valuable researcher and contributor to the PFA. He was brought onto the project by the OERA.

A passionate scientist and teacher with a keen interest in the history of the Scotian Margin, Andrew explains the purpose of a PFA.

"A Play Fairway Analysis is essentially an analysis of all the relevant geological data to where oil and gas may occur within a particular region. You're more or less scoring in a ranking sense the places where the potential is high versus the places where the potential is low for the occurrence of oil and gas. It's all founded on the scientific information about how the system has changed over its history, and how it may have generated and trapped oil and gas sometime during that history," he explains.

Andrew points out that for oil and gas companies offshore exploration is a global high-stakes game with billions of dollars in play, and lowering the stakes can give competitive advantage to a region looking for the lucrative revenues generated by exploration activities.

"It is a worldwide game they're playing and you have to show that your particular area is reasonably well understood, and there's an untested potential there; that's more or less what it's about," he says.

While the goal of the PFA sounds simple, the process of assembling it was anything but. Spearheaded by the OERA, the PFA involved coordinating and integrating the information and data from

10 diverse projects. Each project employed teams of industry experts and world class geoscientists, who worked collaboratively, exchanging data and findings over the course of their work.

Andrew's research was part of the biostratigraphy project. Biostratigraphy, in offshore petroleum research, uses the study of microfossils within rocks to analyze the age and paleoenvironment of sedimentary layers over time. This helps set or refine, as Andrew puts it, the historical clock for a region—in this case the Nova Scotian Margin.

Andrew's contribution to the PFA involved painstaking and meticulous extraction and analysis of microfossils from small chips of rock from drilling exploration wells on the Margin. Microfossils would number in the thousands, Andrew explains, in a chip no bigger than your fingernail. Along with the sheer volume of microfossils to contend with, there was also the variety.

While Andrew studied primarily palynomorphs, a fancy term he says for microfossils with organic walls that include things like pollen and spores from plants, others on the team focused on equally relevant but different microfossils.

"The thing that might be a little surprising, even though biostratigraphy already sounds like a fairly specialized subject, within it there are different groups of fossils that are worked on, and many are not my specialty," he explains.

Researchers were carefully analyzing the microfossils at each well and then cross-checking their results within their own team's areas of expertise. The results would then be cross-checked once more with other multi-disciplinary team findings to ensure what was being construed from the data was sound. The result in the PFA was an updated, or in some regions, a new historical clock of geological events over time.

"You are calibrating time through the well, and that's ultimately giving you a history of what's happening in the Margin," Andrew explains.

Andrew says that while linking the research undertaken in the PFA to potentially successful oil and gas exploration may feel circuitous, it is really not. Understanding the sediments and their depositional history over time is a key component to determining where oil and gas may be located in the future. In particular, the history provides important clues as to where source rocks that produce oil and gas, and the sedimentary structures that trap it, are located in the Margin.

"It's a fairly long and windy route to get from the research I do to the trap that gets drilled

by an oil and gas company. But you have to understand the geological story to understand where those traps might be, and furthermore whether they still contain oil and gas, because if you have one aspect of that history wrong, then your trap will fail. So even though I'm not in the business of finding a trap, I'm generating information relevant to where those traps might be, when the oil and gas might have been generated, and where the source rocks might be."

Andrew says that the efforts of his team, and the work of other teams, would not have been possible without the OERA. It was, he explains, a massive undertaking with complex coordinating and implementing challenges being executed in a tight two-year time frame.

"The analogy I've sometimes used is putting together the Play Fairway Analysis was like putting together a quilt, and we were all working on separate little parts of it and stitching it together, and the OERA was more or less coordinating the whole process. Drawing the resources that were necessary to manage a project this large in that sort of time-frame was a really big challenge, and the OERA was really what made it happen," he says.

So how has the Play Fairway Analysis impacted on the oil and gas exploration story in the Margin?

Andrew says he's not an expert at quantifying the results, but he points out that exploration is currently underway on the Margin, something that probably wouldn't have happened if the PFA hadn't found areas of untested potential.

In October 2015, Shell began drilling the first of two deep-water wells in Nova Scotia's Shelburne Basin. This is part of a renewed $1 Billion dollar commitment to offshore oil exploration on the southwest coast.

BP has also launched an exploration program, the Scotian Basin Project, with the acquisition of 4 exploration licenses located 300 kilometers offshore and a commitment of just over $1 Billion dollars. Since its inception, the Play Fairway Analysis has been expanded to include the Laurentian Basin and the Central Scotian Shelf.

There is also the promise of another player. In 2015 Statoil was the sucessful bidder for 2 exploration licenses located 250 kilometers from Halifax, and a commitment of $82 million dollars.

Like all good scientific research endeavors Andrew says the PFA is an ongoing concern, with new questions to explore and answer.

"In a way, like science, the Play Fairway Analysis is never done, it just has a current status," he says.

ENGAGING WITH INDUSTRY

- Hosted six successful bi-annual Nova Scotia Energy R&D Conferences with >1200 delegates
- Delivered 15+ workshops
- Ability to bring private sector partners to the table in collaborative research consortia

FACILITATING PARTNERSHIPS

- Collaborated with federal, provincial government partners and academic institutions
- Foster collaboration between government, academia and industry through collaborative R&D opportunities, including the newly created Industry Academic Partnership Fund
- National & international collaborations with Innovate UK, France Energies Marines, University of Massachusetts-Dartmouth, Research Council of Norway, and others

SUPPORTING NOVA SCOTIA'S ACADEMIC RESEARCH CAPABILITIES

- Student Research Travel Program has sent 45 students around the globe to participate in science research
- Mentored six student interns since 2013
- Participation of 200+ students in OERA student poster competitions over multiple conferences and workshops

ADVISORY TO GOVERNMENT ENERGY POLICY

- Unique collaborative model – government, community, industry, research, and academia
- Hosted and facilitated tidal and geoscience workshops

RESEARCH ACTIVITY

- $32M in research projects (geoscience, tidal, and seismic & marine sound projects)
- Developed >30 requests for proposals
- Processed and vetted >500 research proposals
- Recruited 150 subject matter experts to peer review proposals and research reports

IMPACT

- Approximately $75M has been invested by industry to support tidal energy and device deployment
- The Play Fairway Analysis has directly resulted in offshore Nova Scotia exploration investments in excess of $2.1B
- 60+ tidal energy projects, 45+ geoscience projects, and 10+ seismic/marine sound projects
- $10M+ in research project leveraging
- 100+ researchers funded
- Research priorities set for each sector
- Development of focused and commercially oriented R&D programs

Building on Success

OERA Highlights 2006-2016

Collaborative Partners

Thank you to our partners for their commitment to developing offshore energy research in Nova Scotia. An investment in time and effort with OERA is an investment in Nova Scotia's energy future. A selection of our partners include:

Acadia Tidal Energy Institute (ATEI)

Acadia University

Atlantic Canada Opportunities Agency (ACOA)

Canada Nova Scotia Offshore Petroleum Board (CNSOPB)

Canadian Association of Petroleum Producers (CAPP)

Cape Breton University

Dalhousie University

Defence Research Development Canada (DRDC)

Eureka

Fisheries & Oceans Canada (DFO)

France Energies Marines (FEM)

Fundy Energy Research Network (FERN)

Fundy Ocean Research Center for Energy (FORCE)

Fundy Tidal Inc. (FTI)

Genome Atlantic

Geological Survey of Canada (GSC)

Innovate UK

Innovacorp

IRAP Program

Marine Renewables Canada

Maritimes Energy Association

MITACS Program

Nova Scotia Department of Energy

Nova Scotia Department of Environment

Nova Scotia Community College

National Research Council (NRC)

National Sciences and Engineering Research Council (NSERC)

Saint Mary's University

St. Francis Xavier University

University of Massachusettes - Dartmouth

Our Team

Stephen Dempsey
Executive Director

Nalani Perry
Operations Manager

Carey Ryan
Director,
Research & Business Development

Russell Dmytriw
Research Manager

Jennifer Pinks
Research Manager

Karen Fraser
Financial Advisor

Board of Directors

Dale Keefe (Chair)
Vice-President Academic & Research (Provost) at Cape Breton University

Richard Isnor (Vice Chair)
Associate Vice-President, Research & Graduate Studies at St. Francis Xavier University

Jeff Somerville (Treasurer)
Partner at Venor Search Group

R.A. Sandy MacMullin (Secretary)
Executive Director of the Petroleum Resources Branch within the Nova Scotia Department of Energy

Joshua Leon
Dean of Engineering at Dalhousie University

J. Kevin Vessey
Associate Vice President of Research and Dean of Graduate Studies at Saint Mary's University

Robert MacKay
Principal of RA Mentor Strategic Consulting

Elisa Obermann
Executive Director of Marine Renewables Canada

David MacKinnon
Dean of Research and Graduate Studies at Acadia University

Lesa Tanner
Atlantic & Eastern Canada Business Development Manager at WesternGeco

Wayne St-Amour
Dean of Applied Research at the Nova Scotia Community College.

Bruce Cameron
Executive Director of the Sustainable and Renewable Energy Division within the Nova Scotia Department of Energy

Joseph Howe Building, Suite 1001,
1690 Hollis Street
Halifax, NS B3J 1V7

Telephone: 902-406-7011
Fax: 902-406-7019

For more information and to review our financial information please visit:

www.oera.ca

The OERA would like to acknowledge the following organizations for use of their photographs:

- Black Rock Tidal Power Inc.
- Cape Sharp Tidal
- Communications Nova Scotia
- Fundy Ocean Research Center for Energy (FORCE)
- Photographic Services, Shell International Limited