Advancing Estuarine and Coastal Science and Ocean and Climate Literacy

Proceedings of the ACCESS/BoFEP Conference/13th BoFEP Bay of Fundy Science Workshop, Truro, Nova Scotia, 17-21 May 2022

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Preface

The ACCESS/BoFEP Conference, entitled "Advancing Estuarine and Coastal Science and Ocean and Climate Literacy" was held from May 17th to 21st, 2022, at the Cox Institute of Agricultural Technology, Dalhousie University, Truro, NS. For the first time, a BoFEP workshop was co-sponsored with the Atlantic Canada Coastal and Estuarine Science Society (ACCESS), a regional organization focused on university research on estuaries and coastal waters. The meeting was co-chaired by Drs. Jeff Clements, DFO-Moncton, and Chair, ACCESS, and Peter Wells, Dalhousie University and Chair, BoFEP. The meeting was the 13th of BoFEP's biennial workshop series, begun in 1996, and helped to recognize the 25th anniversary of BoFEP. It was also the first in-person meeting held since the outbreak of the Covid pandemic in March 2020, the meeting for that year being abruptly cancelled after much preparation.

The conference offered university investigators and their students, government scientists and managers, and personnel from the private sector an opportunity to present their recent aquatic and environmental research, especially that pertaining to the Bay of Fundy and its watersheds. Over 130 people attended in person and on-line, over four days, presenting 48 talks, 22 posters, 2 plenary presentations (one on ocean and climate literacy), 2 panels (the linkage between ocean education and climate change; ecosystem services and dykeland decision making), and a well-attended public forum addressing the implications of sea level rise to coastal flooding in the upper bay. It is clear that there is a vibrant research community in the Maritimes addressing a wide range of aquatic and terrestrial questions and issues, with much emphasis on utilizing the latest techniques, especially genomics. The quality of the graduate student research was especially outstanding.

The conference ended with awards being given for best student papers and posters. As well, Dr. Jeff Ollerhead, a coastal geomorphologist from Mount Allison University, Sackville, NB, was the recipient of BoFEP's Environmental Stewardship Award, recognizing his many contributions to salt marsh restoration and protection in the upper Bay of Fundy.

Dr. Jeff C. Clements, DFO, Moncton, NB and Chair, ACCESS.

Dr. Peter G. Wells, Dalhousie University and Chair, BoFEP.

March 2023.

Acknowledgements

Workshop Organizers

Many people were involved in the organization and conduct of this Conference. They are owed many thanks for their time, expertise and dedication to estuarine and coastal science. In alphabetical order, they include:

Karel Allard, ECCC, Sackville, NB, and BoFEP
Michael Butler, IOI-Canada, and BoFEP
Dr. Gail L. Chmura, McGill University, and ACCESS
Dr. Jeff C. Clements , DFO-Moncton, and ACCESS
Sandra Currie, FORCE and BoFEP
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Lauren Lowther, Dalhousie University and BoFEP
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Susan Rolston, Seawinds Consulting and BoFEP
Kate Spooner, MAPC, Truro, and BoFEP
Dr. Sarah Stewart-Clark , Dalhousie University
Dr. Peter Wells, Dalhousie University and BoFEP

Core Sponsors of ACCESS and BoFEP

Coastal and Estuarine Research Federation; Environment and Climate Change Canada; FORCE (Fundy Ocean Research Centre for Energy); and Hoskin Scientific.

Exhibitors

Hoskin Scientific set up an excellent exhibit and manned it throughout the conference.

In Memoriam

We dedicate these Proceedings to the memory of Dr. Joseph Kerekes, a long-term member of the BoFEP Steering Committee. He passed away in September 2022, at the age of 90, after an exemplary career in limnology with Environment Canada.

Dr. Joe Kerekes viewing a loon nest at Kejimkujik National Park, during a summer of the Loon Watch. Dr. Kerekes published his last paper in 2022 in the PNSIS, Vol. 52, Part 2, p. 197-202, a truly remarkable achievement. Photo credit: Peter Hope

Workshop Program

	Tuesday, May 17	Wednesday, May 18	Thursday, May 19	Friday, May 20	Saturday, May 21
8:00 8:15 8:30 8:45		Registration Welcoming remarks	Registration	Registration	Optional self-guided field trip
9:00 9:15 9:30 9:45		**Plenary 1** *Ocean and Climate Literacy - Strengthening the Linkage Between Ocean Education and Climate Change Action in Our Coastal Waters* **Dr. Wendy Watson-Wright**	**Plenary 2** *The World is Our Oyster: Presence, Partnerships, and Patience* **Dr. Rod Beresford** and **Anita Basque**	**Session 6** *Nature-Based Solutions*	
10:00 10:15		*Morning break*	*Morning break*	*Morning break*	
10:30 10:45		**Session 1** *Research in the Bay of Fundy - Then and Now*	**Session 3** *Terrestrial Land Use and Aquaculture*	**Session 7** *Parasites*	
11:00 11:15 11:30 11:45				**Session 8** *Isotopic Advaces in Marine Ecology*	
12:00 12:15 12:30 12:45		*ACCESS AGM / Lunch break*	*Lunch break*	*Lunch break*	
13:00 13:15 13:30 13:45	**Pre-conference workshop** *Introduction to systematic reviews and meta-analyses* **Dr. Jeff Clements**	**Session 2** *Ecology of the Bay of Fundy*	**Session 4** *Natural and Anthropogenic Stressors*	**Session 9** *Physical Processes*	
14:00 14:15				*Afternoon break*	
14:30 14:45		*Afternoon break*	*Afternoon break*	**Session 10** *Ocean Literacy, Natural History, and Ecology*	
15:00 15:15 15:30 15:45		**Session 2 (continued)** *Ecology of the Bay of Fundy*	**Session 5** *It's in the Genes*	**Awards and Closing**	
16:00 16:15 16:30 16:45		**Panel Discussion 1** *Ocean and Climate Literacy - Strengthening the Linkage Between Ocean Education and Climate Change*	**Panel Discussion 2** *ResNet: Understanding Ecosystem Service Delivery to Inform Dykeland Decision-making*		
17:00 17:15 17:30 17:45		**Poster Session 1**	**Poster Session 2**		
18:00 18:15 18:30 18:45					
19:00 19:15 19:30 19:45	**Welcoming Social** *Cash bar available*		**Public Town Hall** *Implications of Sea Level Rise and the Isthmus of Chignecto*		
20:00 20:15 20:30 20:45					

1. Plenary

Ocean and Climate Literacy - Strengthening the Linkage Between Ocean Education and Climate Change Action in Our Coastal Waters

Dr. Wendy Watson-Wright, Founder and CEO, 7 Mile Bay Vice-Chair, United Nations GESAMP

This presentation was primarily concerned with the international context of ocean and climate literacy. It spoke of the ocean and its challenges, its interactions with climate, the ocean within the UN context, literacy (both ocean and climate), and finished with thoughts on roles that BoFEP and ACCESS might consider with respect to ocean and climate literacy.

The Ocean: It is exceptionally important to refer to the ocean in singular for two reasons: 1) because there really IS only one vast interconnected global ocean (which is the first principle of Ocean Literacy (OL)) and just because various regions of the ocean are named differently does not mean they are separate; and 2) more pragmatically, if we expect people to protect the ocean, we know that humans tend to care about and to look after things MUCH more if they know they have only ONE of them, not several.

The ocean covers 71% of the Earth. Figure 1 depicts well that all the land mass on the planet could fit easily into International Waters alone, and whereas Canada is the second largest country by land mass, it is tiny compared to the ocean.

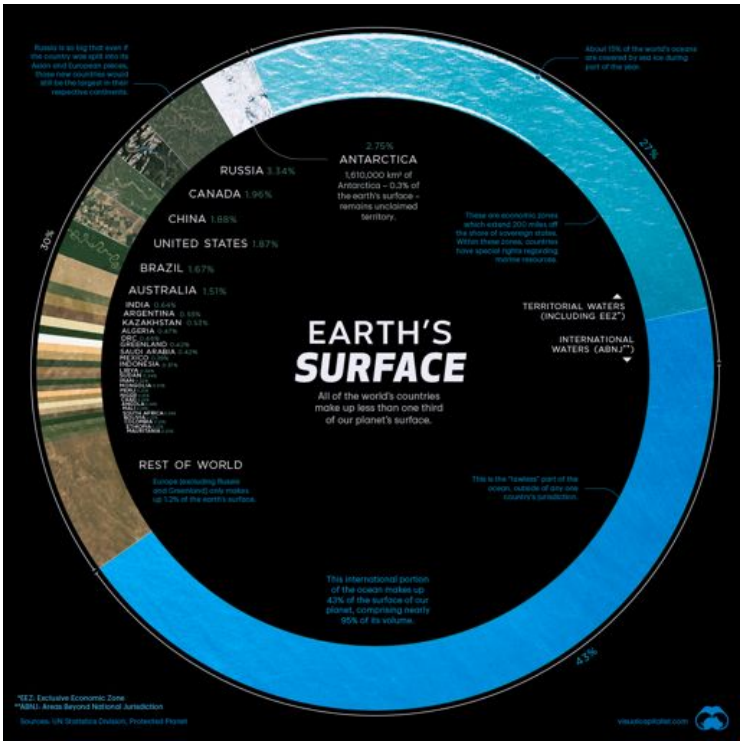

Fig 1. Visualization of share of Earth's surface (https://www.visualcapitalist.com/countries-by-share-of-earths-surface/)

The ocean provides 2/3 of the value of all the natural services offered by the planet, and at least 50% of the oxygen. It has cushioned the blow of climate change; it regulates our weather and provides food for billions of people. The ocean is decisive for the future of the planet, and it is upon all of us to protect it. But we can neither manage, nor protect, what we do not know, hence the need for ocean literacy. Yet the global ocean is facing MANY threats, only some of which are shown in Figure 2.

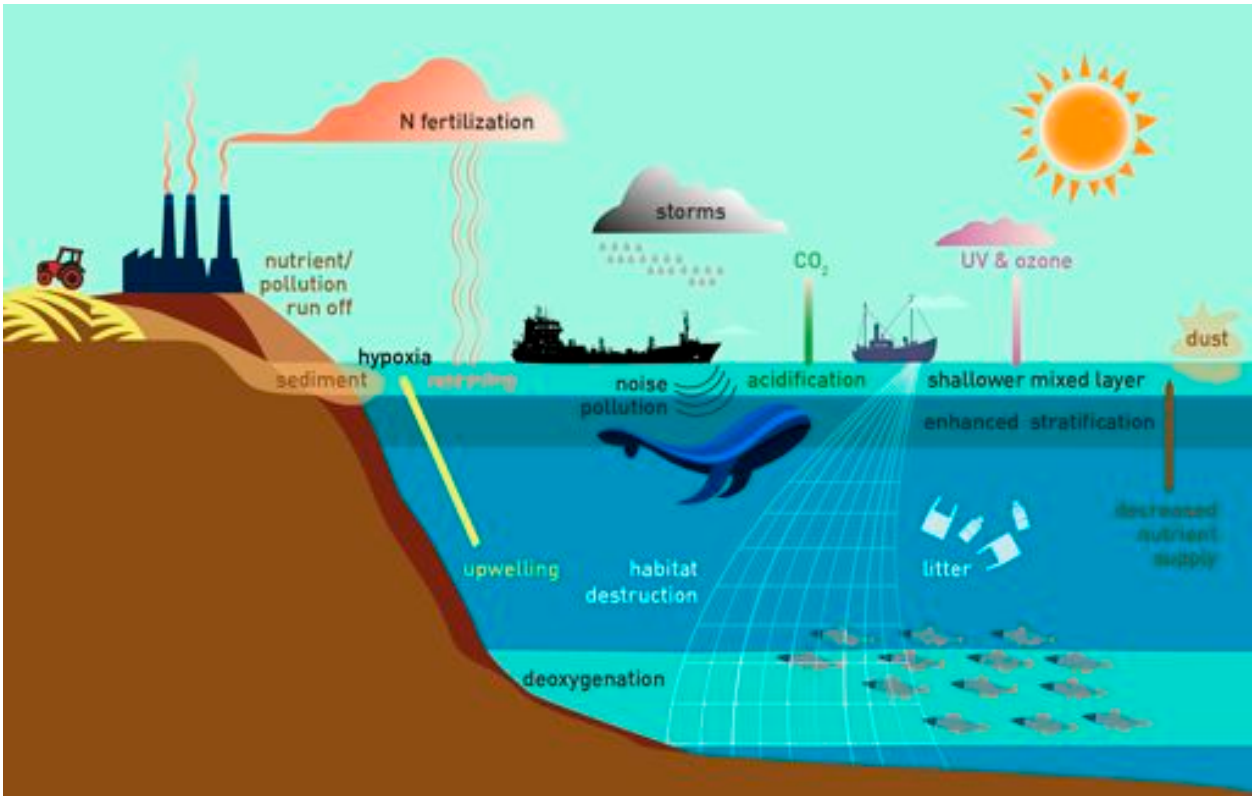

Fig 2. Fig 1: Illustrative examples of global (warming, acidification), regional (ozone, litter, atmospheric pollutants) and local (sedimentation, pollution, and nutrient runoff) stressors, all of which can affect marine life (after IOC-UNESCO, 2022; https://unesdoc.unesco.org/ark:/48223/pf0000380891)

The Ocean and Climate: The ocean is a major driver of climate. It operates as a giant thermostat that regulates global temperature and as a giant flywheel, both moderating change and prolonging it once it has begun. Without the ocean, we would have much higher levels of CO2 concentration in the atmosphere and would experience accelerated global warming, due to the fact that the ocean acts as a carbon sink, absorbing approximately one quarter to a third of annual anthropogenic emissions and storing roughly 50 times more carbon than that in the atmosphere.

The ocean is also a recipient of effects from climate change and carbon emissions, which include ocean warming, ocean acidification and deoxygenation leading to increased dead zones. These in turn are causing additional impacts including sea level rise, loss of biodiversity, changing species migration, and other follow-on effects. Of these, ocean warming may prove to be the most devastating.

The ocean and the UN: Within the UN, there are 24 agencies, programs, divisions and conventions that play important roles in ocean issues. Only three of them have mandates entirely focused on the ocean, with the Intergovernmental Oceanographic Commission of UNESCO (IOC-UNESCO) being one of them and the UN lead for ocean literacy. The 17 UN Sustainable Development Goals (SDGs) which were

adopted in 2015 are a universal call to improve the lives and prospects of everyone, everywhere. Of importance is that the ocean has its own goal, SDG 14, Life Under Water, and that the UN Ocean conferences of 2017 and 2022 focused entirely on that goal. Ocean literacy figured prominently in the Call to Action from the first conference, and later that same year the UN proclaimed the UN Decade of Ocean Science for Sustainable Development 2021-2030 which is coordinated by IOC-UNESCO. One of the ten challenges articulated for the Decade is 'changing the relationship of humanity with the ocean', where ocean literacy is key. As for the ocean and climate, it took many years of constant effort for the ocean to be included in negotiations within the UN Framework Convention on Climate Change (UNFCCC), but it was not until COP 26 in 2021 that the ocean was given prominence. Since then, the UNFCCC has devoted a portion of its website to the ocean, indicating progress is finally being made

Ocean and Climate Literacy: The ocean literacy guide and principles were developed in 2004 in the US with the European Union and other countries becoming involved later. Interestingly, the climate literacy guide and principles, which were published in 2009, quite clearly used the OL principles as a model. And while some see the existence of two separate guides as possibly problematic, the 2021 Canadian OL Strategy and Plan among others considers climate literacy to be a part of ocean literacy. Given the ocean and climate are inextricably linked, this makes sense.

Thoughts for ACCESS and BoFEP: The two organizations can be very effective in bringing forth the message that the ocean and climate are tightly linked. To do so, it will be important to define the audience, finalize the message, ensure the actions fit within the Canadian Ocean Literacy Strategy, and determine which organizations will be the most appropriate partners. The choice of partners of course comes back to the question of who the target audience will be.

Conclusion: In a recent editorial in the Proceedings of the Nova Scotian Institute of Science, Wells, Butler and Eger wrote "Clearly, ocean and climate literacy are inextricably linked". This is absolutely true, and BoFEP, ACCESS and Atlantic Canada could be instrumental in promoting this message. This part of the world could also be a leader in research and information on the ocean and the risks and benefits it offers for human health, as outlined in an upcoming article, *The ocean and human health as a meta-discipline: opportunity for Atlantic Canada,* to be published in PNSIS 52-2, 2022.

2. Panel Session and Public Forum Abstracts

2.1 Ocean and Climate Literacy - Strengthening the Linkage Between Ocean Education and Climate Change

Moderator: Mike Butler, Director of the International Ocean Institute, Canada; Dalhousie University
Panelists: Kerri McPherson, Laura Barrett, Sondra Eger and Phillip J. Prosper

2.2 ResNet: Understanding Ecosystem Service Delivery to Inform Dykeland Decision-making

Moderator: Jeff Ollerhead
Panelists: Kate Sherren, Jeremy Lundholm, Danika van Proosdij, Lara Comejo, CBWES

2.3 Public Town Hall- Implications of Sea Level Rise and the Isthmus of Chignecto

Moderator: Sarah Steward-Clark
Panelists: Tim Webster, MP Stephen Ellis, NS Public Works

3. Contributed Paper Session Abstracts

Abstracts and extended abstracts for contributed paper sessions are listed in the order presented by session. The full Workshop program is available at https://access.wildapricot.org/resources/Documents/ACCESS-BoFEP%202022%20Final%20Program.pdf

3.1 Research in the Bay of Fundy – Then and Now

Chair: Gail Chmura

Celebrating BoFEP's 25th Anniversary – Reflections and Future Steps to Enhance Ocean and Climate Literacy

Peter **Wells**[1], Jon A. Percy[2], and Graham R. Daborn[3]

[1] *International Ocean Institute – Canada, Dalhousie University, Halifax, NS*
[2] *SeaPen Consultants, Granville Ferry, NS*
[3] *Acadia Centre for Estuarine Research, Acadia University, Wolfville, NS*

Abstract

This paper describes the early beginnings, accomplishments, recent activities, and new directions of BoFEP on the group's 25th anniversary. BoFEP is a virtual and in-person information and knowledge network for the Bay of Fundy's coastal and marine environments. The challenges and next steps for the organization are especially important, in an era of climate change, increased demand for natural (living) resources, and greater development pressures along the ever-changing shorelines of the Bay. For the

foreseeable future, BoFEP's principal focus will be on communicating information on the Bay with its broad network of partners and developing ways to enhance ocean and climate literacy in the schools and communities around the Bay.

Introduction

The Bay of Fundy, with its huge tides, extensive watersheds, natural resources and wildlife is one of nature's coastal and ocean wonders. It is world-renowned and unique globally, the region being recognized with six UNESCO sites, the latest being the Cliffs of Fundy Geopark in the Minas Basin, upper Bay of Fundy.

However, over many decades, many species in the Bay such as cod, salmon and herring have diminished in numbers, and pollution (chemicals, litter, plastic) and physical disturbance threaten the health of estuaries and nearshore environments. Expansion of open-pen fish aquaculture and over-exploitation of resources, including tidal energy extraction, may have unintended consequences. Despite the Bay's size, macro-tidal exchange and ecosystem diversity, the multiple and cumulative stresses warrant believing that the ecosystem health of the whole Bay may be at risk. Such issues and concerns constantly require research and monitoring, followed by effective information transfer to policy and decision makers and the public to ensure appropriate management action and effective conservation and protection measures where needed.

Most of the earlier research on the bay was on its living resources, i.e., fisheries species, under the guidance of the Fisheries Research Board of Canada (Huntsman 1952, Johnstone 1977, Hubbard *et al*. 2016). Environmental research in the region spiked in the 1970s and 1980s (Gordon et al. 2014) and then for several years focused largely on the potential impacts of proposed tidal power developments in the Upper Bay (Gordon et al. 2014, Gordon and Dadswell 1984). However, all of the proposed Upper Bay tidal developments were based upon construction of tidal barrages and were eventually shelved because of environmental concerns and cost. The exception was the construction of a demonstration tidal power station built in the early 1980s into the existing Annapolis Causeway, in the Annapolis Basin, the first such installation in North America. Until that time, only a few researchers outside of some universities (e.g., Acadia, Mount Allison, UNB, Dalhousie) were looking at the Bay of Fundy as a whole ecosystem, examining the many ecological processes and stresses comprehensively, the potential for interacting and cumulative effects, and the possibility for long-distance effects resulting from the biological connections of the Bay with the Arctic, North and South Atlantic, and North, Central and South America **(**Brylinsky et al. 1997**,** Hicklin 1987**).**

Up to the mid-nineties, there had been dramatic declines in a number of fish stocks throughout the region (especially cod, halibut, herring, halibut), jeopardising the economy and livelihood of local coastal communities. Coastal birds, especially migratory species, had also fallen in numbers or had inexplicably changed their distributions (P. Hicklin, CWS, pers. comm.). Periodic fatal collisions between ships and the North Atlantic Right whales, as well as entanglement with fishing gear, threatened the recovery of its small population; unfortunately, this is still occurring. Ship traffic and ecotourism seemed to be interfering with feeding, nursing and mating activities of whales, as well as disturbing important seabird colonies.

In the upper Bay, continuing loss of remnant salt marshes and changes in the mudflats, both natural and man-made, threatened the species dependent on these habitats, particularly the various species of shorebirds. There were reports of great fluctuations in abundance and distribution of some bottom dwelling and intertidal animals. In some parts of the Bay, sewage contamination and sedimentation had

closed once productive clam flats. The accumulations of organic wastes from large open-pen aquaculture operations seemed to have degraded nearby benthic habitats. Ominously, scientists were reporting a range of chemical contaminants (toxic chemicals) in the seawater, bottom sediments and tissues of numerous marine animals (Wells, Keizer, Martin *et al.* 1997, Chase *et al*. 2001, Burt and Wells 2010).

In many areas, marine seafloor habitats were being degraded by intensive, highly mechanised and destructive harvesting such as bottom trawling and scallop dragging. Causeways, dams or bridges have obstructed most large rivers flowing into the Bay (Wells 1999), and there were clear indications that these were altering sediment transport, water flow and related natural processes in some areas. On one such causeway built across the Annapolis River at Annapolis Royal, the turbines of a new tidal power plant were killing and maiming many passing fish, such as American shad and Atlantic sturgeon (M. Dadswell, pers. comm.), and may have contributed to the declines of shad and striped bass, and disappearance of sturgeon from the river.

Marine scientists familiar with the Bay were alarmed by the number of such ominous reports. They were puzzled that many of the changes that were visible or easily measured could not be readily explained by what was known about the oceanography and ecology of the Bay. Just over a decade earlier, scientists had reviewed knowledge about the Bay as part of a major environmental assessment of a proposed large tidal power project in Cumberland Basin, as well as conducting a major review of the Gulf of Maine of which Fundy is a part (Gordon and Dadswell 1984, Backus 1987). They were confident in having a reasonable understanding of many of the significant oceanographic and ecological processes in the Bay. However, considering their uncertainty about more recent changes, it was clear that this complex ecosystem needed another close look, especially if it was to be adequately protected against significant human-caused change.

Preparing A New Knowledge Synthesis On The Bay Of Fundy

The concept of a multi-partner organization (that eventually evolved into BoFEP) to address this challenge emerged in the mid-1990s from an initiative by a small team of interested people, led by Environment Canada (EC) and Acadia University (Acadia Centre for Estuarine Research or ACER). The team of eight persons[1], calling themselves the Fundy Marine Ecosystem Science Project (FMESP), met frequently throughout 1995 at ACER. They discussed the various worrisome environmental trends in the Bay of Fundy, especially the suspected changes in sediment quality in intertidal areas used by migratory shore birds, a major concern of the Canadian Wildlife Service (CWS-EC). They began to document the range of environmental issues in the bay, based on current research and the literature, noting the disturbing signs of a diminished environmental quality and biodiversity in many parts of the Bay of Fundy.

After initial discussions, members of FMESP launched a process to address the following five broad questions:

1. What is happening in the Bay of Fundy marine ecosystem, with particular emphasis on the Upper Bay?
2. Is our knowledge of the ecosystem sufficient to understand what is happening?

[1] The Fundy Marine Ecosystem Science Project (FEMSP) team consisted of Dr. Mike Brylinsky (ACER), Dr. Graham Daborn (ACER), Alison (AJ) Evans (independent consultant), Steve Hawbolt (CARP – Clean Annapolis River Project), Peter Hicklin (CSW-EC), Dr. Jon Percy (SEAPEN), Dr. Peter Wells (CWS-EC), and Louise White (DFO-BIO).

3. What else do we need to know?
4. How are we going to find the answers?
5. How can we use the evolving scientific understanding in support of continued management for conservation and protection of the Bay's ecosystem?

A draft background report on current knowledge of the Bay was written with chapters authored by FMESP members and other invited scientists. Each chapter had a bibliography of published research, a summary of the current understanding of each topic, and a list[2] of the most pressing issues facing the Bay. The draft report, entitled "Bay of Fundy Issues", was completed by Fall 1995. It was then circulated as a discussion piece to invitees to a workshop involving some 60 scientists and managers from around the Bay, held at Acadia University in January 1996.

The meeting itself, deemed the first Bay of Fundy Science Workshop[3], was the first of 12 such biennial workshops, held around the Bay of Fundy up to May 2022. In addition to summarizing a wealth of scientific information and suggestions for further research, the workshop in 1996 concluded that addressing the problems facing the Bay could not be accomplished only by scientists and environmental managers. New work had to involve a much broader coalition of interested persons and groups, including First Nations groups, living resource users or fishermen, conservation groups, and residents of coastal communities.

The edited report and a summary of discussions at the workshop, stimulated by the five broad questions, were published by Environment Canada as "Bay of Fundy Issues: A Scientific Overview" (Percy *et al*. 1997). In a draft action plan in the report, the proposal was made to set-up a more diverse organization focused on communication and new initiatives addressed by the working groups.

Establishing BoFEP and Its Mission

A special meeting took place at the subsequent (2nd) Fundy Science Workshop held in November, 1997, at the Biological Station, St. Andrews, NB. This workshop was held jointly with the Ecological Monitoring and Assessment Network (EMAN) of Environment Canada; it attracted over 160 participants (Burt and Wells 1998). The Bay of Fundy Ecosystem Partnership (BoFEP) was launched at an evening meeting with the aim to be an inclusive "Virtual Institute" focussed on communication. A program was developed, including a mission and vision statement, which over the 25 years has proven to be a useful guide to the groups work.

The BoFEP mission, under the mantra of "creating, sharing and using information", is to promote the ecological integrity, vitality, biodiversity and productivity of the Bay of Fundy ecosystem, in support of the social well-being and economic sustainability of its coastal communities, and to facilitate and enhance communication and co-operation among all citizens interested in understanding, sustainably using and conserving the resources, habitats and ecological processes of the Bay of Fundy.

The BoFEP vision is predicated on several general principles**:**

[2] 38 issues were identified by the workshop attendees and the report authors – this proved to be a useful guide to the topics addressed by BoFEP working groups.

[3] It should be noted that there were numerous other Bay of Fundy workshops in the 1970s and 1980s, largely published through ACER (Acadia University). The 1996 workshop was the first in a series sponsored by BoFEP.

- Conservation, protection and management of Bay of Fundy resources and their habitats should be ecosystem-based and reflect a holistic understanding of ecosystem structure, processes and interactions.
- Resource development and other coastal zone activities should be based on ecologically sound, integrated coastal planning and management.
- Coastal planning and management should be transparent and open to participation by resource users, coastal communities, industries, scientists, governments, managers and all other individuals and groups with interests in the Bay of Fundy ecosystem.
- Effective communication and active co-operation among all citizens with an interest in the Bay of Fundy, and linkages with groups and programs that share similar objectives are vital to this enterprise.

To advance this mission and vision, BoFEP was organized as a geographically dispersed, adaptable, responsive and inclusive network (a "Virtual Institute") linking all of its partners to: facilitate timely sharing of information about the Bay; foster effective communications and cooperation among each other; promote and facilitate the regular assessment of the Bay's ecosystem; identify specific issues and priorities; and promote and facilitate long-range planning and integrated coastal management for the Bay of Fundy.

BoFEP's Program and Accomplishments, 1997-2022

The BoFEP program has been managed and directed with a simple management structure. Two strategic plans, with member input, have guided the organization's focus and work. The priorities have been communicating Bay of Fundy information to a wide audience, sharing new knowledge through its biennial science workshops and other focused meetings, running themed working groups, and conducting specific research projects with partner interest and support.

An overview of accomplishments to date follows, along with the description of the group's focus and objectives for the foreseeable future. The BoFEP website (www.bofep.org) has the detailed reports.

Communication – Knowledge Of The Bay

Fact sheets – "Fundy Issues"

From the outset in the wake of the first Fundy workshop, a priority was to prepare short *"fact sheets"* on a number of important environmental issues confronting the Bay, as well as on other Fundy topics of particular interest, hence fulfilling part of the public communications mandate. These "Fundy Issues" were researched and written on contract until 2010 by the senior author (Percy) in an impartial and non-technical way, then distributed in both print and e-versions. Printed versions were widely distributed at each workshop and proved popular. All 33 documents are on the BoFEP website, organized by theme.

A number of topics not yet addressed, e.g., species at risk in the Bay, implications of coastal erosion, whales and tourism, still require such summaries and some require updating. This is important now, given our current focus on ocean and climate literacy in schools and coastal communities. Writers for these are needed and distribution should include tourism centers as well as schools.

BoFEP's Newsletter

Fundy Tidings is the quarterly e-newsletter of BoFEP published on the website. Each edition has submissions from BoFEP members, partner organizations and individuals with an interest in the Bay of Fundy. Articles include information about BoFEP and its activities, information about partner organizations and their activities, and timely news items pertaining to the Bay of Fundy. The newsletter is sent to the large list of "members", whether they are paid members or not. Currently, there are approximately 350 people and groups on the distribution list.

BoFEP's Website

Since the late 1990s, the website (www.bofep.org) has become the main visible "voice" of the organization. It is the depository for its products (such as those above) and is a visible source of information about current BoFEP activities. Its design has evolved and it is has an active Facebook page. Its importance to the organization's goals cannot be overstated. At this point in BoFEP's ongoing program, and given the ongoing rapid change in how people access information, i.e., through social media, a full time webmaster is required to manage and lead the redesign of the site.

Communicating New Research and Networking - Fundy Science Workshops And Other Meetings

The Biennial BoFEP Bay of Fundy Science Workshops

Since its first meetings of 1996 and 1997, BoFEP with its partners has conducted ten subsequent Fundy science workshops, in different locations in NS and NB. A range of themes has been covered, from understanding change in the Bay to protecting watersheds and estuaries, and the protection and conservation of their species and habitats. Proceedings of these meetings are always published and made available on the website. Their publication has evolved from hard copy and CD, to simply being posted on the website (and in the Google Cloud Platform). Some hard copies of early Proceedings remain for those interested.

These workshops have accomplished a major goal of BoFEP – to bring together researchers (both established and in training), environmental and resource managers, educators and other interested persons from a range of organizations to periodically exchange current information on the Bay, to network, to generate new ideas about projects and solutions, and to bring a focus to the need to sustainably manage this unique coastal ecosystem. Attendance over the years, ranging from 100-150, reflects the success of the workshops.

After the interruption caused by the Covid pandemic (2020-22) and the cancellation of the Workshop for 2020, the 12th workshop/conference was held in May 2022, co-sponsored by ACCESS (Atlantic Canada Coastal and Estuarine Science Society) and BoFEP. The venue was both in-person and on-line. It was a great success, pointing to the continued need for such communication opportunities focused on the Bay. Discussion is already underway for the 13th Bay of Fundy Science Workshop, to be held in New Brunswick in 2024.

Special Forums and Workshops – co-sponsored with partners.

Over the years, a number of other subject-focussed meetings have been held, involving multiple BoFEP partners and sponsors, and most of them producing reports (all on the website). They include:

- Coastal Barriers 2000 – this addressed the ongoing concerns about the ecological impacts of dams and causeways on the many rivers and estuaries around the bay, especially their effects on migratory fish and seabirds. This followed earlier work pertaining to a potential tidal barrier on Cumberland Basin (Gordon and Dadswell 1984) and a report by Environment Canada in 1999 (Wells 1999). The Coastal Barriers meeting brought considerable renewed attention to the issue, especially pertaining to the Petitcodiac River causeway in Riverview-Moncton, which subsequently was partially opened up to enable more adequate water flow and fish passage. That decision came from active community-based pressure.
- Minas Basin Community Forums, 2000-2002. The four discussion meetings led by BoFEP included many members of the communities around the Basin and produced comprehensive reports about the priority concerns of residents (on the BoFEP website). Unfortunately, these were not followed up by the members of the Minas Basin WG, which was subsequently disbanded. There is still an opportunity for follow-up, especially given the current focus on the Minas Basin's prospects for tidal energy and increased tourism, and on the upper/inner Bay of Fundy's conservation priorities of sustainable fisheries and protection of migratory shorebirds.
- The GPAC-BoFEP Coastal Forum 2002, "Taking the Pulse of the Bay", part of the 5th BoFEP Workshop, held in Wolfville, NS. This workshop focussed on the issue of land-based pollution around the Bay, a focal point of the United Nations Environment Programme, Global Programme for Action (GPAC) in the 1990s.

Other themed meetings and studies sponsored by BoFEP and its partners have included:

- Threats to the Health of the Bay of Fundy: Potential Problems Posed by Pollutants - workshop 2010 (Burt and Wells 2010).
- Tools for healthy watersheds 2011.
- Mitigating Impacts of storm water, wastewater, etc. 2012.
- Climate Change in the Bay of Fundy 2013.
- Workshop for development of an Ocean Health Index (OHI) and report, 2015.
- Talking Circles in NB, conducted up to 2018.

Reports from almost all of these multi-partner meetings and studies are on the BoFEP website. A review of these reports to see what has been done or not, following from their summaries and recommendations, would be insightful and could still be considered in BoFEP's work plans or followed up at future workshops.

BoFEP's Working Groups

From the outset, given the number of Fundy issues identified at the first workshop in 1996, it was envisaged that focused Working Groups would be the action-oriented arm of BoFEP. Members from the different partner organizations would work collaboratively on new "concrete activities", including scientific research, environmental monitoring, communication on critical problems, and information synthesis.

From the late 1990s, a number of WGs were set up, chaired by different members of the BoFEP community and with participants chosen for their interest and expertise. Each WG has had a highly motivated champion as Chair, was highly focused, and has had a different history and longevity. Reports from their work are on the website. Talks, panel sessions and posters were often given at the various workshops, describing their progress and products.

To date, the groups have included:

The Fundy Biosphere Reserve WG - it operated for several years, with the support of Fundy National Park and local environmental groups. Its work led to the submission to UNESCO for establishment of a formal UNESCO Biosphere Reserve in the Upper Bay of Fundy on the New Brunswick side. There continues to be an active group looking after the Reserve which maintains an informal affiliation with BoFEP.

The *Corophium* & Mudflat Ecology WG - it operated from 1999 to 2006 from Mount Allison University with NSERC funding and published extensively on its research findings (e.g., Hamilton *et al*. 2006). The research work is still ongoing, through MtA and UNB Fredericton. Again, members of the research teams are affiliated with BoFEP and are always actively engaged in reporting on their research at the biennial workshops.

The Fundy Informatics WG at Dalhousie University – this group met several times in the early 2000's and soon evolved into the ongoing Environmental Information: Use & Influence research program, centered in the School of Information Management and funded by three SSHRC grants (see www.eiui.ca). It has been running over 20 years now, with many research students and many publications (e.g., Soomai *et al*. 2013), including a book (MacDonald *et al*. 2016). The group is always active at the biennial workshops and members are on the BoFEP Steering Committee.

The Minas Basin WG – it was long-running and very active, chaired by ACER at Acadia University, had a wide range of participants from different sectors, and brought a focus to the myriad of community interests and concerns in the Basin. It produced a number of reports, notably some from the community meetings held around the Basin in 2002-05 (reports on the BoFEP website). It ceased its work after its excellent Chair, Dr. Mike Brylinsky (ACER), passed away in 2015 and ACER research was redirected to tidal power development and its potential ecological impacts, and other ecological topics in the Upper Bay.

The Outreach WG - on two occasions, with core BoFEP members, it led discussions about BoFEP's goals and objectives and developed two Strategic Plans, 2011 and 2020, to guide the organization. Both strategic plans are on the web, the most recent one describing our current direction and activities.

The Salt Marsh & Restricted Tidal Systems WG – This group, active in the early BoFEP workshops and all subsequent ones, quickly evolved into a major research initiative led by Saint Mary's University and the private sector. Its members always give papers and often chair panels at the biennial workshops, given the importance of salt marsh and dyke management in this era of climate change (more severe storms, coastal erosion, flooding of low lying areas).

The Stress & Cumulative Effects WG was established by the late Dr. Mick Burt of the HMSC and UNB Fredericton, and Peter Wells, following the second EMAN/BoFEP workshop (1997). The WG addressed fisherman's concerns about open pen salmon farming and potential impacts on local fisheries. The WG held a well-attended workshop in 2010 in St. Andrews, on pollution impacts in the lower bay, and produced a report (Burt and Wells 2010).

There were other working groups that operated for short times, then disbanded for various reasons; they included the Sublittoral Ecology & Habitat Conservation WG and the Tourism WG, centered in Parrsboro NS and which engaged partners interested in Fundy tourism for a short while.

Recently, following discussion at the 2018 BoFEP Bay of Fundy Workshop, the Ocean Literacy WG was set up and is now becoming active as the Ocean and Climate Literacy WG (2022) (M. J.A. Butler, pers. comm.). In the wake of two panel discussions on the topic at the workshops, it is developing an active agenda (as of Dec. 2022).

To summarize, the concept of the working groups was to engage a wide range of people and partners in joint discussions, followed by new, innovative and much needed research on the most outstanding environmental and resource problems confronting the Bay of Fundy. The groups worked independently, sought funding when required, and reported progress at the biennial workshops. Some WGs were short-lived, some went for many years with many successful projects (Minas Basin), and others quickly evolved into separate programs (EIUI – www.eiui.ca). Many of their reports are on the BoFEP website.

As can be seen in this paper, the concept of partner driven WGs is alive and active, strongly supported by both Strategic Plans and the broad open discussions at the 2018 workshop. For success, every WG on a key issue must have a committed champion to inspire and lead the work. People count!

Conducting Specific Research Projects

Over the past two decades, BoFEP obtained funding from government departments to conduct or oversee specific projects of interest to both groups. These projects produced new information, as well as providing modest overhead funds to cover the conduct of BoFEP. Reports on all of these projects are on the website. They include: Ecological risk assessment for Fundy: DDT and mercury; Identification of chemicals of emerging concern in the Bay of Fundy watershed; A century of monitoring Prince 6 Site in the St. Croix River Estuary; Producing an Ocean Health Index (OHI) Score for the Southwest NB Bay of Fundy, Marine Resources Planning Area; A Thirty Year Assessment of the Cornwallis River Estuary, Nova Scotia; Reviewing emerging environmental issues in the Bay of Fundy (for Environment and Climate Change Canada); and Living Shorelines – a natural approach to shoreline management. Information from these projects was reported at the biennial workshops and reports are on the BoFEP website (www.bofep.org).

Conduct of such projects ceased in 2018 due to the shortage of people willing and able to seek funding and manage such projects, a very time intensive process for members of a volunteer organization.

BoFEP at 25 Years – Challenges and Next Steps

Many environmental and living resource issues (concerns) still confront the Bay of Fundy and its watersheds, and the greater Gulf of Maine, especially in this era of rapid climate change. These include the effects of sea level rise, increasingly severe storms, the impacts of increased numbers of open-pen aquaculture sites, municipal and industrial water pollution from cities such as Saint John, increasing water temperatures and ocean acidification, shifts in copepod abundance and distribution and resultant effects on the foraging areas of the northern right whales, the potential for oil spills, and effects of river barriers and tidal power devices on migratory fish. Our multi-partner workshops and those sponsored by the Gulf of Maine Council illustrate our collective ongoing commitment to track progress addressing such issues, to encourage their study and understanding, to report on them with the most reliable information available, and to point to solutions wherever possible.

BoFEP continues to be run by a small management team or committee, elected by the multi-partner Steering Committee after each AGM. Both committees are filled with committed volunteers, despite increased work loads, competing priorities, potential burn-out, and more recently the stress of an

ongoing pandemic (2020 to date). We have had and still have challenges. The 2011 BoFEP Strategic Plan (see www.bofep.org) was an excellent operational guide but was only partially implemented due to a change in personnel and a focus on specific Fundy projects for several years. The projects were successful and provided primary funding and some overhead, but did not encourage a move towards a more solid institutional structure, supported by a paid BoFEP membership. Hence, these projects provided little basic support for the organization's core role – information synthesis, communication and networking.

During this period 2010 onwards, the interest of important governmental partners such as ECCC and Fisheries and Oceans (DFO) waned, despite successful BoFEP workshops in 2009 (Wolfville), 2011 (Saint John) and 2014 (Halifax, with the Coastal Zone Canada Association). The negative impact of the federal Conservative government (2006-2015) policies on the environment was profound, in terms of reducing the civil service in the environmental sector and general funding for environmental NGOs. This government also destroyed the once proud system of marine and aquatic science libraries across the country (from nine to two), including the closure of the venerable and historic library at the Biological Station (SABS), in St. Andrews, NB, and loss of irreplaceable materials (Wells 2013, 2014, Hubbard *et al.* 2016). For the Bay of Fundy, the development of tidal power has dominated as an issue of concern and has redirected attention and funding. The long term BoFEP Secretariat and scientific support at ACER, Acadia University, one of the centers for Fundy environmental research and a major supporter of BoFEP, was closed.

Finally, despite recruitment to the Steering Committee (SC) remaining steady, engagement of SC members in BoFEP's activities has proved challenging, despite various retreats and meetings. Sadly in recent years, several of the most active older members on our BoFEP management team have passed away. A younger management team is needed, one with members actively engaged in Fundy research and projects but with time and energy to be involved in BoFEP.

BoFEP currently is fortunate to have the continued in-kind support of a range of partners active in the Bay of Fundy region - SEAPEN, FORCE, Ocean North, MAPC, DFO, several universities, CARP, IOC-Canada, and occasionally others. The group has been an active member of the Gulf of Maine Council (GOMC) Working Group since 2006, an important partner with a wide perspective of environmental and resource issues in the greater Gulf of Maine. Although our primary support for many years came primarily from the government and the universities, not from other NGOs and the private sector, this has started to change and many groups attend our workshops.

BoFEP especially needs to strengthen the partnership with First Nations groups, given their involvement with fisheries and conservation and long history in the region; we are very fortunate to have two members on the management committee. A workshop held in February 2022, in St. Andrews, organized by First Nations (H. Akagi, pers. comm.) raised many topics and concerns that should be followed up in future discussions and meetings.

Importantly, during the Covid pandemic, BoFEP continued to operate on-line, keeping projects running and members engaged. It has pointed out the value of on-line meetings and discussion groups, saving expensive, gas-consuming road trips.

The discussions at the 2018 workshop and the subsequent completion of the second strategic plan (2020), as mentioned above, have led to very clear strategic objectives for BoFEP and achievable goals. They include: **Communication** - facilitate information exchange and dissemination; **Outreach** –

workshops and networking, conduct of co-funded projects; **Conduct of working groups** ,as leadership and funding permit; and **Quiet Advocacy** for a healthy Bay of Fundy ecosystem, supporting both living resources and the entire natural environment of the Bay.

BoFEP's 25th year of operation in 2022 was something to celebrate for a non-government volunteer organization. Given the regional and global importance of the Bay of Fundy and its watersheds, the focus will continue to be on Fundy information synthesis and communication, and opportunistically on specific projects. This work will continue under the over-arching theme of ocean and climate literacy, in support of the ongoing UN Decade on Ocean Science and Sustainability, the Sustainable Development Goal (SDG 14), and ongoing global efforts on ocean literacy. Our new working group on literacy is moving ahead full steam.

The constantly updated Fundy-related information can be used in appropriate and effective conservation and protection measures. Along with other organizations and our partners, study of the Bay and its protection and conservation requires a close connection between science and policy making, and above all, public understanding and support. A forward looking informed approach to the Bays management will ensure that local and regional political decision-makers are proactive rather than reactive, and that requires an informed and concerned constituency.

The reader's views on any aspect of the work of BoFEP and this papers content are most welcome. The health and sustainability of the Bay of Fundy's environment and living resources depends upon your informed viewpoints and engagement.

Acknowledgements and Dedication

The authors greatly appreciate the considerable work and dedication of the many people affiliated with BoFEP over many years. We thank the reviewers of this paper, an early version of which was the basis of the talk presented at the ACCESS-BoFEP Conference in Truro, May 2022.
The paper is dedicated to key members of BoFEP's steering committee and its working groups who have left us over the years, most recently the distinguished Dr. Joseph Kerekes. They are honoured in our publications and will be long remembered for their extensive knowledge, hard work, friendship, and dedication to a healthy and sustainable Bay of Fundy.

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An Overview of Interests, Research and Activities in the Minas Basin and Inner Bay of Fundy Over the Past 30 Years

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The purpose of this work is to provide an overview of the breadth of interest, research, and activities in the Inner Bay of Fundy (IBOF) over the past 30 years to understand trends and synthesize current opportunities. The IBOF is of particular interest as it contains many critical habitats that support key ecosystem species and species at risk, has the highest tides in the world, and is at the intersection of a number of provincial and national jurisdictions. An analysis was conducted with 886 documents relating to the Inner Bay of Fundy from a newly constructed Zotero Database. Documents were gathered by reaching out to government staff, researchers, practitioners, and organizations who are known to work in the area as well as through more formal searches of databases, public registries and social media using key words (e.g., Web of Knowledge, Scopus, Twitter, Facebook, Provincial and Federal Government websites, Canadian Newspaper Archives Database). The database therefore contains peer reviewed literature, grey literature, news articles and social media. It is important to acknowledge that this analysis only includes written, publicly available documents and does not include Indigenous knowledge. Results provide a realistic understanding of areas of broad interest (i.e., human activities, physiography/physical geography, ecosystem concept and species specific) a list of relevant actors (who led research and authored documents, etc.) as well as a summary of interests and involvement from different actor groups over time. This work provides the opportunity to highlight opportunities to support and direct future areas of research and engagement in the IBOF.

Quantifying Intertidal Mudflats and Salt Marshes in the Inner Bay of Fundy Pre and Post Dykes

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Researchers from NSCC-AGRG and the Canadian Wildlife Service have partnered to construct a high-resolution GIS database of features in the Inner Bay of Fundy. GIS analysis was conducted to address the following questions: map the head of tide of the major rivers and map the extent of mudflats and salt marshes pre and post dyke construction. Additional information related to the proximity of threats to these ecosystems were also implements. Both NB and NS are now fully covered with topographic lidar and form the foundation of some of the analysis. In the case of NS much of the coastal area was surveyed at low tide, thus allowing the mudflat and salt marsh elevations to be captured. To calculate the head of tide for the major rivers, Higher High Water Large Tide (HHWLT) from the Canadian Hydrographic Service was used to relate to the CGVD2013 vertical datum of the lidar data. The HHWLT ranges from 3.9 m near Digby to 7.2 m in the Minas Basin, to 7.5 m in Truro and 6.7 m in the Tantramar area. The HHWLT data were queried for each river and elevations were then applied to the lidar data to calculate the head of tide location. The inner bay was split into sections based on the HHWLT range and coastal flood inundation maps were constructed for present day and 2100 considering RSL. The intertidal mudflats and salt marshes were extracted using Google Earth Engine where 880 Sential-2 images at 10 m resolution were used.

Salt Marsh Vegetation Mapping Using Sentinel-2 Imagery in Atlantic Canada

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Salt marshes are highly productive coastal wetlands with specialized vegetation adapted to saline environments. Salt marsh conservation and restoration promote ecosystem services such as mitigating coastline erosion, buffering against flooding, and filtrating sediments and pollutants. The combination of anthropogenic use of coastlines and sea level rise leads to coastal squeeze of salt marshes and further urges their protection. Sentinel-2 imagery has several advantages over intensive field-based surveys to assist with mitigation efforts. Our research aims to determine the potential of using Sentinel-2 to monitor salt marsh restoration. We examined whether a single (spring) or multi-temporal (spring and fall) imagery is needed. The images were classified using a non-parametric supervised classifier: Random Forest. The Sentinel-2 images were acquired over the Musquash Estuary, NB, on 25 June 2020 and 18 October 2020 from the European Space Agency (ESA) Copernicus website, to compare restoring and established salt marshes. The Sen2Cor processor was used to perform atmospheric corrections and resample all the bands to a 10 m resolution. The corrected images were then subjected to a supervised classification to create a map with 13 land cover classes. The reflectance imageries and vegetation indices inputted in the Random Forest classifier produced a confusion matrix with associated overall accuracies of 93.45% for June only imagery and 95.48% for combined June and October imagery. Random Forest generated a 'variable of importance' table that ranked Red-Edge_1 and Shortwave-

Infrared_2 as most important input bands in the classification. These results confirm that a multi-temporal imagery is more helpful in remote monitoring of salt marsh than a single imagery.

Open the Floodgates: Understanding Effects from the Manipulation of a Tidal Water Control Structure

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Aboiteaux are water control structures consisting of a tide gate at the end of a culvert that regulates flow between a tidewater area and a drained upland area. Within Nova Scotia, the Department of Agriculture maintains over 250 aboiteau structures originally designed to drain freshwater from agricultural marshlands while preventing tidal entry. While the use of aboiteaux dates to the original Acadian's of the 17th Century, there is recent recognition that water control structures should consider the physical, chemical, and biological effects they have beyond their primary purpose of flood control. NSDA is working with researchers and knowledge holders to investigate opportunities for integrating improvements into existing and future aboiteau structures. As part of a recent tidal wetland restoration project in Onslow, Nova Scotia, testing of various gate manipulations on a three-cell aboiteau were performed. High-resolution ortho-mosaics, digital surface models, time-lapse photography and field observations were collected and compared to modeling results and hydrodynamic data to determine the impacts on hydraulics, channel morphology, tidal influence, flood extents and sedimentation. As anticipated, in general, the larger the gate opening the greater the tidal influence upstream. Water levels upstream were notably impacted by minor structure manipulations and sedimentation build-up immediately upstream and downstream were directly influenced by opening size and location. Future research, including improved baseline studies, monitoring, and design will be required to help better understand the physical, chemical, and biological effects that aboiteaux have as tidal water control structures to minimize their ecological impact while continuing to provide flood control.

Filling The Gap: Marine Spatial Planning For Minas Basin Ebsa

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Currently, information surrounding species distribution and habitat modeling for the Minas Basin is non-existent, unavailable, or held throughout multiple organizations despite becoming nationally recognized as an Ecologically and Biologically Significant Areas (EBSA) in Canada in 2012. This state of Minas Basin data availability and publication does not meet the standards required of an EBSA or aid any future developments and/or management decisions. This project aims to increase the availability of environmental and species data through collaborative data sharing and accessible data communication

efforts.
We are building a collaborative environment for environmental and species data from all known data providers. We are creating functions that automate common data wrangling tasks, removing obstacles to data compilation and structuring, and aiding process documented for repeatable science. Once data is cleaned, exploratory data analyses identify what spatial and temporal analyses are possible, and describes data structure and variability. These efforts also provide a current state of spatial-temporal occurrences of fish and invertebrates within the Minas Basin. This project lays the foundation for collaborative research to generate outputs that will aid in future conservation and management decisions for the EBSA.

3.2 Ecology of the Bay of Fundy

Chair: Jeff C. Clements

An Inter-Connected Benthic To Pelagic Baseline Of The Bay Of Fundy Marine Food Web

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The Bay of Fundy is a diverse ecosystem supporting a complex ecological network of native, invasive, and migratory species. Several of these species have well understood ecology and life history characteristics (e.g. North Atlantic right whale); however, the resource pathways that fuel these species are understudied. Marine food webs are typically fuelled by two primary food chains, the pelagic and benthic, which can be coupled by both biotic and abiotic processes. This interaction and transfer of nutrients, energy, and mass between the pelagic and benthic food chains underpin the food web processes supporting these charismatic species. Therefore, a thorough understanding of the Bays' food web is required to elucidate the source and fate of organic material within the Bay. We used stomach contents and stable isotope analysis of carbon and nitrogen, to assess the diet of 41 fish and 49 invertebrate species in the Bay to estimate how benthic and pelagic resources are coupled in this ecosystem. Contrary to our expectations, the data suggests that the benthic and pelagic food chains are quite distinct within the Bay, suggesting that pelagic detritus may not be fueling the benthic food chain as observed in other systems. The Bay has some of the largest tides globally and the movement of such a large volume of water could also be displacing coastal production which ultimately settles on the seafloor as a resource for benthic consumers. This study will provide information about the connectedness of the ecosystem and assist in improving management and conservation practices.

Potential Role Of Ice Blocks And Wrack On Sediment And Plant Transport In Tidal Marshes

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Bay of Fundy tidal wetlands are dynamic ecosystems characterized by repeated natural disturbances. Ice blocks can remove vegetation and sediments but can also transport these within and between wetland sites. Dead vegetation often washes up as "wrack" on wetland surfaces and can transport seeds. There is little research regarding the capacity of ice and wrack to transport viable plant propagules onto marshes where they can colonize. We sampled ice blocks and wrack in Minas Basin tidal marshes, determined sediment quantity contained in ice blocks and assessed the viability of seeds and rhizomes contained in both ice and wrack. Ice blocks contained sediment at densities between 0.01 and 4.75 g·cm-3, indicating an estimated 26.61 – 21,483.59 kg per block, representing a large source of sediment. Contributions of sediment by ice may be important to raise marsh platforms to elevations appropriate for plant colonization. We found viable propagules from halophytic and non-halophytic species in wrack, and viable propagules of salt hay (*Spartina patens*) in ice. While the wrack survey on Minas Basin sites revealed viable seed from several halophyte species, subsequent restoration experiments at two Bay of Fundy and two Atlantic coast sites showed no effect of wrack addition treatments on vegetation recovery, possibly due to variability in the seed content within wrack. Our results indicate that ice and wrack represent potential sources for vegetation colonization at tidal marsh sites but more research is required to understand the temporal and spatial variability in these potential sources of sediment and plant propagules.

The Connections Between Temporal Variation Of Managed Realignment Inlet Conditions And Deposition Variation Across A Restored Marsh Surface

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As sea levels rise, coastal flooding increases, and our current hard engineering sea defenses will get increasingly expensive to maintain. Nature-based solutions, such as salt marsh restoration, are starting to be recognized for their effectiveness and self-sustainability. Salt marshes have the ability to attenuate waves and storm surges, providing flood protection, however, salt marshes must rise and move inland to survive sea level rise. Managed realignment (MR) projects are allowing salt marshes to move inland, but it is unknown if salt marshes can accrete enough sediment to keep up with sea level rise, thereby continuing their protective services. This thesis will measure spatial and temporal patterns of short-term variables to discuss with accretion rates in a managed realignment site in the Bay of Fundy and how this can be used to improve restoration trajectory models. Sediment flux and hydrodynamic data will be measured seasonally using an acoustic Doppler current profiler, ISCO automated water sampler, acoustic Doppler velocimeters, and turbidity sensors, co-located in the channels and inlet. Sediment deposition and grain size will be measured using a combination of sediment traps and individual-tide surface scrapes across the marsh surface, co-located with marker horizons and rising stage bottles across the site. This research will inform future modeling scenarios, carbon storage potential studies,

and adaptation to sea level rise that can increase our understanding of the restoration trajectory of managed realignment sites.

Comparison Of Early Vegetation Dynamics In Salt Marsh Restorations With Different Initial Conditions

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Salt marsh restoration accesses ecosystem services in coastal areas where they have been lost or degraded from anthropogenic activities. Our objective is to compare the early restoration trajectories of vegetation during salt marsh restoration projects in multiple locations and with different starting conditions. We are interested in defining critical phases of restoration that are specific to a project's location and site history, as well as those that can apply regardless of these. In New Brunswick, we have 4 restoration projects of various ages: in Aulac (11 years after breaching the dike, former pastureland) and Rockland (1 year, freshwater impoundment) in the upper Bay of Fundy, Musquash (3 years, impoundment) in the outer Bay of Fundy, and Rivière-du-Nord (1 year, impoundment) in the southern Gulf of St. Lawrence. Using stratified random quadrat sampling, we annually monitored the vegetation in these sites since the projects began. In Aulac (our oldest project), we have identified the critical phases as: large amounts of sediment deposition reflecting elevational disparity between restoration and reference sites, and distinct transitions in the vegetation community which is currently dominated by low and high elevation halophytes (including *Spartina alterniflora* and *S. patens*). For the projects starting from impoundments, the elevational disparities between restoration and reference sites are small and the previously mentioned distinct phases of vegetation change have simultaneously occurred within the first few years of restoration. Our work contributes to best practices for salt marsh restoration in the diversity of soft-sediment shorelines, tidal regimes, and site histories in Maritime Canada.

Movement And Habitat Use Of Late Season Migrant Shorebirds In Maritime Canada

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Each year the Bay of Fundy and Northumberland Strait host large populations of shorebirds in late summer and fall. The Bay is an essential staging location for Semipalmated Sandpipers (*Calidris pusilla*) and movements of this species have been well studied. In contrast, the Northumberland Strait hosts a wider variety of species that have received less attention – in particular late season migrants. As timing of arrival varies by species, temporal changes in prey availability and temperature may affect foraging behaviour, fattening rates, and movement patterns. To understand movement ecology and temporal

changes in habitat use, we are focusing on three Calidrid sandpiper species – White-rumped Sandpipers (*Calidris fuscicollis*), Sanderling (*Calidris alba*) and Dunlin (*Calidris alpina*). These species migrate late in the season, after most of the summer migrants have departed. Between August and October in 2021, birds outfitted with radio tracking tags at Petit Cap Beach, New Brunswick were monitored using the Motus Wildlife Tracking System. Previous work and preliminary results from this study suggest that Semipalmated Sandpipers use different staging strategies, with some remaining on the Northumberland Strait and others moving into the Bay. Dunlin appear to have a similar strategy, with a portion of the tagged birds transitioning into the Bay of Fundy and others remaining on the Strait. Conversely, White-rumped Sandpipers and Sanderling tend to remain on the Strait where they were tagged. This work will enhance our understanding of regional shorebird movements and habitat use throughout the season, to make more informed decisions when managing and protecting key habitat.

Breeding Origin Of Semipalmated Sandpipers Staging In The Bay Of Fundy And Northumberland Strait During Southbound Migration

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Semipalmated Sandpipers (SESA) are long distance migrant shorebirds that make extensive use of habitat in Maritime Canada during their annual southbound migration. The Bay of Fundy is recognized as critical habitat for these birds, but many also use habitat on the Northumberland Strait. Populations of SESA have declined substantially in the past several decades, and sources of these declines are unclear. SESA breed across the Arctic and identifying the origin of birds using coastal habitat in the Maritimes is an important step in understanding migratory connectivity and potentially population trends for the different breeding groups. To address this knowledge gap, we obtained feather samples from juvenile SESA captured from 2018 to 2021 in the Bay of Fundy and Northumberland Strait. Feathers were analyzed for the stable isotope of deuterium, then mapped onto an established isoscape that allows us to estimate breeding origin. As expected, most of our birds originated in the eastern Arctic, but there was also a sizeable subset that appeared to come from central regions. Early arriving birds were more likely to be of eastern origin, and in one year when the entire migration was unusually early the proportion of eastern birds was higher. This may suggest a particularly successful breeding year in that region of the Arctic, and that timing of arrival of SESA in the Maritimes may reflect their origin. We also detected differences in isotope signatures between Bay and Strait birds, suggesting possible differences in habitat use on migration among breeding populations.

Fish Use Of Salt Marshes In A Megatidal And Microtidal Environment

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The hydroperiod (i.e., the frequency and duration of flooding) dictates when intertidal areas of salt marshes are accessible to fish and nekton. Maritime Canada presents a unique opportunity to examine how hydroperiod impacts fish use of salt marshes due to the contrasting tidal regimes that exist along the coasts. Salt marshes in the Bay of Fundy are flooded less frequently and for shorter durations of time than those in the Northumberland Strait. We looked to compare the fish communities using intertidal creeks and the foraging patterns of a resident and transient fish species between both tidal environments. Using fyke nets, we sampled the fish and nekton communities using intertidal creeks at 3 sites in the Bay of Fundy and 3 sites in the Northumberland Strait. A sub-sample of mummichog and Atlantic tomcod were retained for gut content analyses to further assess how tidal regime might impact foraging patterns. Fish communities using Bay of Fundy intertidal creeks were found to be dominated by transient species and have lower species diversity than those in the Northumberland Strait. Common mudflat species were abundant in the guts of fish captured in Bay of Fundy marshes, while fish caught in Northumberland Strait were consuming sand shrimp and detritus. Our results suggest that Northumberland Strait marshes are more accessible to a variety of fish species, and that marshes in the two regions offer different foraging opportunities to fish. Understanding the communities and foraging patterns of fish using these ecosystems is valuable information when looking to set salt marsh conservation and restoration objectives.

Using Telemetry To Deepen Knowledge Of Frostfish (*Microgadus Tomcod*, Punamu) And Their Spawning Migrations In Bay Of Fundy Tidal Rivers

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The Atlantic tomcod (*Microgadus tomcod*, punamu) is a gadid fish abundant in North Atlantic coastal waters from Labrador, Canada south to Virginia, USA and is a valuable resource for many predators. It is also known as "frostfish" given its resilience to cold waters and that it spawns further inshore during the winter months in estuaries and freshwater streams. It has been fished as a minor commercial and recreational species and has traditionally been used as a winter food source by Mi'kmaw First Nations communities throughout its range for generations, most notably in the Bay of Fundy region of Atlantic Canada. Despite its local relevance, abundance and widespread distribution, there has been little scientific research on its ecology and movement. In this study, we tagged 186 tomcod over 2 years with acoustic transmitters to investigate their seasonal spawning migrations from November through February from adjoining tidal river systems in the Bay of Fundy to potential spawning areas. Preliminary findings indicate that pre-spawning tomcod in the area may exhibit some site fidelity to the southern coastal region of the bay. Incoming data will be used to investigate potential patterns relating to

spawning migration and space use. This research is part of a collaborative project between Mi'kmaw knowledge holders, commercial fishers, academia, community partners, government and other local stakeholders. Results will be used to inform management approaches and strategies for Atlantic tomcod in local regions to enable better stewardship of this culturally significant fish.

Establishing A Baseline For Benthic Invertebrate Community Monitoring In Saint John Harbour, New Brunswick.

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Infaunal invertebrates are often used as indicators of the health of coastal marine environments, although these communities are also influenced by many other factors, including sediment characteristics. Saint John Harbour hosts one of Canada's busiest ports, a city of over 65,000 people, and a range of industries. To monitor the health of the harbour, it is necessary to establish a baseline condition against which to compare potentially contaminated sites and future changes. Six subtidal sites in the harbour were selected to be representative of soft sediment habitat while being sufficiently distant from potential contaminant sources. Sediment samples were collected from these reference sites from 2011-2014 and 2017-2021, and analysed for invertebrate community composition, total organic carbon, sediment grain size characteristics and levels of trace metals and polycyclic aromatic hydrocarbons. The data were used to examine differences among sites; to identify possible temporal changes in invertebrate communities and contaminants; to establish a baseline for 'normal' conditions; and to investigate how sediment properties and contaminant levels interact to drive invertebrate community composition. Invertebrate abundance, diversity and species composition varied among sites, with higher diversity in the outer areas of the harbour. Contaminant levels were generally low at the reference sites, although inner areas of the harbour had higher levels of some contaminants. Some variation among years was apparent, although there was little evidence of marked directional change. This presentation will explore these patterns and the relationships between the invertebrate community and the physical / chemical sediment environment in Saint John Harbour.

Infaunal Invertebrate Community Response To Altered Sediment Carbonate Chemistry In The Bay Of Fundy

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In the coastal environments, eutrophication and ocean acidification both decrease pH and impact the abiotic conditions experienced by marine life. Open ocean pH has already declined due to anthropogenic CO2 emissions, and it is projected to decrease 0.15 pH units more by 2050. Algal blooms due to eutrophication can also increase CO2 and decrease pH through decomposition. Infaunal invertebrates are exposed to more extreme pH conditions than epifauna, as porewater pH is typically lower than the overlying water. Here, we investigated the impacts of altering sediment carbonate chemistry, through

the addition of transplanted green algae and/or crushed shell hash, on the infaunal community. This factorial field experiment was conducted on an intertidal mudflat in New Brunswick, Canada from July to September of 2020. After one month, sediment pH was impacted by the addition of shell hash but not algae. Community composition was impacted by an interaction between algae and shell hash treatments in month one. Communities were more similar between plots when algae was absent or when high amounts of shell hash were added. In month two, the sediment pH and community responses to the experimental treatments disappeared. This was likely due to the washing away of the shell hash, suggesting regular maintenance if used as a remediation technique. Due to the complexity of the processes driving sediment pH and carbonate chemistry in the coastal ocean, further experiments focusing on drivers and effects of sediment acidification are required to deepen our understanding of the impacts on infaunal marine species.

3.3 Terrestrial Land Use and Aquaculture

Chair: TBD

Modeling Reforestation's Role In Climate-Proofing Watersheds In Nova Scotia From Flooding And Soil Erosion

Robert **France**

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The mitigation potential of reforestation for offsetting the deleterious effects of increased flooding and soil erosion projected to occur in Atlantic Canada through future climate change was investigated. Modeling determined a strong but non-linear relationship between extent of vegetative cover and runoff volume and discharge rate for the Salmon River watershed in Nova Scotia, suggesting that reforestation will reduce, but not completely prevent, flooding. Predicted erosion rates were found to be progressively reduced in relation to the extent of upland reforestation. Of three scenarios examined in which 60%, 65%, and 85% of the entire watershed is randomly reforested, only the latter would reduce the elevated erosion expected to occur through climate change back to present-day existing levels. Additional modeling revealed that comparable mitigation of soil erosion can ensue through implementation of 70 m streamside buffer strips, which would only take up 19% of the total surface area. Prioritizing riparian zones for reforestation will therefore subsume less of the overall productive land area and therefore enact a less severe socio-economic impact on agriculture and forestry.

Climate Change Predictions Of Increased Watershed Flow In Atlantic Canada: Implications For Surface Water Vulnerability And Ameliorative Land Use Management

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Atlantic Canada is expected to experience elevated rainfall due to climate change over the next century. A predictive modeling study of a coastal watershed in Nova Scotia was undertaken to investigate the potential of riparian reforestation to mitigate the deleterious environmental effects projected to occur from future climate change. Increases of 9 to 25% in flow were predicted for the Thomas Brook watershed throughout the rest of the century. A GIS model was adopted for assessing changes in surface water vulnerability based on land-use and landscape topography estimates of nutrient loading, sedimentation, runoff, wetland loss, and stream geomorphology. This model indicated that increases in drainage intensity and drainage sensitivity expected through the climate change model resulted in greater proportions (from 5 to 27%) of the watershed area being classified as “High vulnerability” for impacting surface water quality. In terms of land use planning, implementation of runoff and nutrient entrapment techniques through low impact development may need to become increasingly required in order to maintain estuarine health. In terms of land-use management, empirically increasing the width of riparian forest buffers was projected to reduce the predicted areal extent of “High vulnerability”, but that widths of 90 m would be required to achieve the same degree of protection as exists presently. The conclusion is that climate-proofing this watershed through riparian reforestation would come at a cost in terms of the extent of land needed to be set aside by being taken out of agricultural production or commercial forestry.

Effects Of An Aquaculture Fish Farm To The Sediment Geochemistry Of A Naturally Anoxic Basin

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Whycocomagh Basin is a deep, naturally anoxic basin located in the Bras d'Or Lakes, Nova Scotia. Presently a Steelhead Trout (*Oncorhynchus mykiss*) aquaculture farm leased by the Waycobah First Nation operates as an economic resource. However, hazards associated with free sulfide accumulation following anaerobic processes pose challenges to sustainable management practices for the fish farm pens. Accumulation of total dissolved free sulfide (S2-= H2S + HS- + S2-) concentrations can reach toxic levels in the bottom water and sediment, and it could impact fish in floating pens at the surface and the surrounding biogeochemical environment. Porewater chemistry, microsensor profiling, and CHN analysis of the sediment-water interface, both below and away from fish pens, were collected to assess the fish farm impacts on the sediment geochemistry and to understand the influence of the farm on the natural biogeochemical cycles.

Growth And Survival Of Blue Mussels Caged In Saint John Harbour, New Brunswick

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Blue mussels (*Mytilus edulis*) obtained from a commercial aquaculture farm were caged at five of six standard monitoring stations in Saint John Harbour. Stations had been established by the Saint John Harbour Environmental Monitoring Partnership (SJH-EMP) in 2010 and have been repeatedly sampled since for the benthic invertebrate community and contaminants. Mussel caging is the third indicator in the SJH-EMP monitoring program and is intended to complement the benthic measures with a measure of the health of the water column. UNBSJ doctoral student Vince McMullin demonstrated the feasibility of caging mussels at the six standard monitoring stations in 2012-2014. Mussels were weighed and measured before deployment in June 2021 and again upon retrieval after three months in August 2021. A second caging of similar duration was begun in August 2021 and ended in early December 2021. Mussel tissues from both cagings were analyzed for accumulated metals. In addition to providing information judged to be a gap for Saint John Harbour (i.e., water quality inferred from caged mussel survival, growth and contaminant accumulation) this monitoring program, supported by DFO-Maritimes Region's Coastal Environmental Baseline Program, is intended to build environmental monitoring capacity within Wolastoqey Nation in New Brunswick. This talk presents challenges encountered and progress made in the development of this monitoring program, results to date and plans for the future.

Immune Response Of Shrimp And Crayfish Species Under The Challenge Of Viral Pathogens

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Viral pathogens are among the most severe threats to wild stocks of commercially significant crustacean species and global aquaculture stocks. With the growing demand for dietary protein sources and the resultant increased use of crustacean species to meet this demand, the control of disease is vital to food security and the continued success of fisheries and aquaculture activities. Upon infection, crustaceans initiate an innate immune response which involves a complex process of activation and differential expression of key immune-related genes. These genes support viral pathogen destruction and preservation of critical physiological functions in the infected host. Our research focuses on the detailed characterization of the genes and molecular mechanisms involved in antiviral immune response in the Northern shrimp (*Pandalus borealis*) and the Northern clearwater crayfish (*Faxonius propinquus*). The immune response shall be characterized under treatment conditions which include a viral mimetic prophylactic and a novel carbohydrate-based nanoparticle conjugate that enhances the effectiveness of the prophylactic treatment. This experimental design aims to reveal (i) the specific nature of the antiviral immune response in each species and (ii) the possible effect of each treatment, particularly the enhancing effect of the nanoparticle conjugate. By characterizing species-specific immune responses,

this project shall provide valuable information which may be used to assess the effectiveness of existing and future antiviral treatments.

Acute Toxicity Of A Tire Rubber-Derived Chemical, 6ppd-Quinone To Atlantic Salmon (*Salmo salar*)

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Salmon returns have been declining. Contributing factors for these salmon population declines are not fully understood and may include a complex array of stressors. An emerging area of research is the role of stormwater runoff and particularly tire-wear particles and their associated chemicals in contributing towards adverse environmental effects.
Mass mortality of adult Coho salmon (*Oncorhynchus kisutch*) returning to freshwater to spawn have coincided with untreated stormwater runoff events, resulting in a phenomenon termed 'urban runoff mortality syndrome' (URMS). URMS is typically considered to be a uniquely Coho problem given its high visibility, however the effect of stormwater runoff constituents on other salmonids and early life stages has not been methodically studied to date. The causative agent(s) behind URMS has been a source of much inquiry, but a recent study (Tian et al. 2020) found the sole culprit contributing to the toxicity in Coho salmon to be 2-anilino-5-[(4-methylpentan-2-yl)amino]cyclohexa-2,5-diene-1,4-dione (6PPD-quinone). 6PPD-quinone is derived by the oxidation of the globally ubiquitous preservative 6PPD that is found in tire rubber (0.4 to 2% by mass in passenger and commercial tire formulations).
Here we present the preliminary findings of the toxicity of 6PPD-quinone to pre- and post-smolt Atlantic salmon (*Salmo salar*) and provide an opportunity for a dialogue regarding data gaps and collaborative opportunities for environmental sampling from urbanized rivers in Atlantic Canada. This project will generate monitoring and toxicity data for watersheds across Atlantic Canada and can help inform management practices and provide insight into potential risks.

3.4 Natural and Anthropogenic Stressors

Chair: Peter Wells

Microplastic Contamination In Coastal Regions Of The Southern Gulf Of Saint Lawrence

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Microplastics (<5mm) in marine and coastal habitats continue to be a contaminant of emerging concern in Atlantic Canada. Originating primarily from the degradation of larger plastic debris deposited in the

marine environment, microplastics become widely distributed and can accumulate in marine sediments where they can leach toxins introduced in the original production processes (i.e., bisphenol A, phthalates). Microplastics can also adsorb hydrophobic background contaminants such as persistent organic pollutants (POPs) which has the potential to bioaccumulate through the marine food web as microplastics become an unintended food source. Microplastic accumulation affects marine and coastal wildlife, increasing mortality and reducing the availability of healthy coastal habitat. This study builds upon work conducted in the Bay of Fundy (New Brunswick and Nova Scotia) and continues to quantify regional microplastic distribution in intertidal marine sediments and the potential for biological uptake by bivalves. Bivalves and adjacent intertidal sediment were sampled from sites along the southern Gulf of Saint Lawrence coastline (New Brunswick, Nova Scotia, and Prince Edward Island). Microplastics were separated from bivalve tissue using a potassium hydroxide digestion. For sediment samples, microplastics were removed by density separation in a concentrated salt solution. Microplastics from both bivalve and sediment samples were inspected under a dissecting microscope (40x). Data analysis will assess the relationship between microplastic concentrations in intertidal sediments and in bivalve and will consider proximity to potential sources of this contamination.

Marine Microplastics Quest With A Novel Method Of Pyrolysis Gas Chromatography-Mass Spectrometry

Ashok **Deshpande**

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An exponential growth in plastic production since the 1950s, combined with poor waste management and recycling practices, has led to widespread plastics pollution that has reached all corners of planet earth, ranging from the Arctic to the Antarctic and from the remote mountains in the French Pyrenees to the bottom of the deepest Mariana Trench. The plastics in the environment embrittle due to the sun and the wave energies, and break down into smaller particles, called the microplastics of grain size lower than 5 mm. Microplastics also enter the aquatic environments directly from a variety of anthropogenic sources, including cosmetics, synthetic clothing, and industrial processes. Microplastics are a cause for concern because their particle size range overlaps with the prey size range ingested by the aquatic animals. Interestingly, not all plastic is created equal. Different plastics are manufactured under different polymerization conditions and may contain different chemical additives. Different plastics exhibit different chemical and physical properties, and different environmental fates and effects. Understanding the nature of microplastics is critical to the identification, and possibly the regulation and mitigation of sources of plastics. The knowledge of polymer composition is also important in the understanding of the fisheries risk assessment. The scientists at the NOAA Fisheries Sandy Hook Laboratory and their collaborators have developed a novel method of pyrolysis gas chromatography-mass spectrometry (GC-MS) for the chemical characterization of microplastics polymer types. In this method, a small piece of the microplastic sample, less than 1 milligram in weight, is placed in a narrow quartz tube which is then placed in a platinum coil and heated to 650-750 degrees C in an inert atmosphere. The intense heat of pyrolysis breaks down the carbon-carbon bonds in the large plastic polymer chains into smaller fragments. The pyrolytic fragmentation patterns thus obtained are reproducible and unique to the given polymer types. These fragments are then transferred to and separated on a gas chromatographic column, and identified by using a mass spectrometer. We have created a pyrolysis GC-MS library of some of the most commonly used plastics polymers. The pyrolysis GC-MS method has been used for the chemical characterization of fresh plastics and weathered plastics

samples from the littoral and aquatic environments. We have also characterized plastics ingested by the seabirds and the sea turtles. The NOAA collaborators include scientists from government agencies, academia, and international institutes. Because of its novelty and its practical applications, the pyrolysis GC-MS internship projects have attracted many NOAA-EPP, NOAA-Hollings, and NOAA-College Supported scholars.

The Effects Of Acute Hypoxia Stress On Transcriptomic Response Of Blue Mussel (*Mytilus edulis*)

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The blue mussel (*Mytilus edulis*) is an important aquaculture species cultivated in Atlantic Canada. However, climate change is threatening the productivity of the industry through changes in the aquatic environment. Physiological responses to hypoxia have been well studied in the blue mussel; however, less is known about how gene expression contributes to homeostasis and physiological responses, especially between different mussel sizes and populations. The present study examined the transcriptomic response of acute (4 h) hypoxia of blue mussels from two populations in Prince Edward Island, Canada (March Water, St Mary's Bay) and two size classes (adult, seed). Heart rate was evaluated to better understand the status of metabolic rate depression. Overall, major changes in gene expression were observed in the first hours of hypoxia exposure associated with metabolism, byssal thread remodeling, immune and stress response, cellular signaling, antioxidant production, growth, and development. Differences were observed between populations and sizes, indicating that differences in environments and physiological status are important in how mussels respond to acute hypoxia. Seed mussels had decreased expression of several growth, development and byssal thread genes, indicating that even acute hypoxia exposure may have negative consequences for the mussel aquaculture industry.

Determining The Impact Of Polycyclic Aromatic Compound Exposure On *Fucus vesiculosis* Using A Germination Assay

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The impacts of a crude oil spill can vary greatly depending on the volume spilled, the chemical composition of the oil, and the environmental conditions at the spill site. Of the 1000s of different compounds found within crude oil, polycyclic aromatic compounds (PACs) are responsible for the majority of the observed toxicity. Should an oil spill reach the shoreline, macroalgal species are likely to be exposed, however little is known about their sensitivity, so it is difficult to predict the potential impacts. Macroalgal species play a critical role in both freshwater and marine ecosystems and function as primary producers and habitat for other aquatic life. The aim of the study was to generate toxicity data to determine the sensitivity of *Fucus vesiculosus*, a common intertidal brown seaweed widely found along Atlantic coastlines, to several individual PACs. Sexually mature plants were collected, then

spawned in the laboratory to generate zygotes which were allocated to glass slides submerged within exposure media. Exposures were completed for 3 PACs and were conducted at 15 and 19°C. Based on germination success *F. vesiculosus* are one of the more sensitive species included in the oil spill effects models and show increasing sensitivity with increased temperature. *F. vesiculosus* is a good model species to include in oil toxicity tests and the data generated in this study can be used to better understand the sensitivity of macroalgae to PAC exposure.

Mussels In Hot Water: The Behavioural Ecology Of Temperate Mussels Under Ocean Warming And Acidification

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[8] *Fisheries and Oceans Canada, Gulf Region)*

Global climate change is anticipated to have wide ranging effects on ecologically and economically important marine biota. Two global change stressors of contemporary interest in the marine realm are ocean acidification and warming (OAW). Herein, the potential effects of OAW on animal behaviour can act as important mediators of ecological impacts. In this talk, I will discuss some of our research regarding effects OAW on valve gaping behaviour of temperate marine bivalves (mussels). Using empirical evidence from laboratory experiments, I will demonstrate that warming, but not acidification, has the potential impact mussels' behavioural responses to predators (valve closures). By combining our behavioural results with previous research regarding OAW effects on mussel ecophysiology, I will argue that the observed effects of warming on mussel behaviour likely contribute to negative effects on mussel ecophysiology. I will close by discussing ways in which these impacts on behaviour and ecophysiology can translate into population- and community-level impacts and lay the groundwork for future work in this arena. Furthermore, I hope to demonstrate that bivalves can serve as a model organism for the field of behavioural ecology.

Twenty Five Years Of Seagrass Monitoring In South Florida: Water Quality, Hurricane Disturbance And Stochasticity

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With over 14,000 km2 of seagrasses, south Florida has some of the most expansive seagrass meadows on earth; and south Florida has a large and rapidly growing coastal human population. Across the shallow coastal marine ecosystems of south Florida, there are pronounced gradients in the relative

availability of nitrogen (N) and phosphorus (P), and a qualitative change in the limiting nutrient. In general, enclosed estuarine waters in the region are exceedingly P-limited owing to the lack of P with respect to N in freshwater runoff and long water residence times. In 1995, in order to provide guidance to managers of the then-newly created Florida Keys National Marine Sanctuary, a monitoring program to measure water quality directly, as well as the impacts that water quality has on the important seagrass and coral reef habitats. Leading indicators, which point to processes affecting the system of interest, as well as lagging indicators, which are descriptions of the results of those processes were established. In this study, we ask first if there is evidence of long-term change in water quality parameters and in seagrass beds in the south Florida seascape over the 25-year period 1995-2020, and if there exists a spatial coherence to any changes. We then examine whether our leading indicators of seagrass condition can be used to attribute the driving forces behind observed changes.

3.5 It's in the Genes

***Chair*:** Sarah Stewart-Clark

Validating The Use Of Environmental DNA To Characterize Fish Communities In Eutrophic Temperate Estuaries

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Nitrogen is the limiting nutrient in most estuaries. Artificial increases result in the mass proliferation of macroalgae like sea lettuce (*Ulva* sp.), which outcompete seagrasses. Seagrass loss is worrisome in the southern Gulf of Saint Lawrence as it is an important habitat for many ecologically and commercially important animals. The Department of Fisheries and Oceans Canada, Gulf Region (DFO-GR), is developing marine environmental quality guidelines to help combat eutrophication in the southern Gulf of St Lawrence. DFO-GR is interested in whether nearshore fish communities can be used as a bioindicator that could be monitored using their community outreach program: the Community Aquatic Monitoring Program (CAMP). CAMP's beach seining effectively monitors nearshore fish communities; however, sea lettuce clogs the seine nets in eutrophic sites, complicating the sampling process. The emerging field of molecular ecology could provide alternatives to seining. One of these techniques being investigated is environmental DNA (eDNA) metabarcoding. As animals move around, they leave behind fragments of their DNA. These fragments can be collected from water or soil samples and used in eDNA metabarcoding to detect multiple target species simultaneously. Our project will investigate if eDNA metabarcoding could replace or complement seining in DFO-GR's monitoring programs, especially in eutrophic estuaries. We will compare the fish communities revealed by eDNA metabarcoding with seining, seeing if similar or different trends emerge in the two methods. New sampling techniques like eDNA metabarcoding could help effectively monitor the status of biodiversity as restoration, and environmental policies are developed and enacted.

Effects Of Nutrient Enrichment And Foraging By Invertebrates And Shorebirds On Microbial Communities In A Hypertidal Mudflat

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The productive mudflats in the Bay of Fundy support abundant fauna which are underlain by diverse assemblages of microorganisms. These microorganisms are producers and decomposers of organic matter, symbionts of most animals and key components of biogeochemical cycles, thus effecting large-scale ecological processes in mudflats. Yet, our understanding of the response of microbial communities to biotic and environmental perturbations remains poorly characterized in mudflats in the hypertidal Bay of Fundy. Our study investigated the response of microbial communities (estimated with environmental DNA metabarcoding) to foraging by shorebirds (mostly Semipalmated Sandpipers, *Calidris pusilla*) and by a macroinvertebrate (the mudsnail *Tritia obsoleta*), and to nutrient enrichment, in a Bay of Fundy mudflat. Exclosure of shorebirds and mudsnails generally did not impact microbial community composition; however, its inconsistent effects may indicate a complex trophic structure, compensatory interactions and therefore a degree of resilience in microbial communities to disturbance. The effect of nutrient enrichment was consistency and complementary between the microbial eukaryotic, bacterial and meiofaunal communities. Specifically, we found that the relative abundances of apicomplexans (unicellular, obligate intracellular parasites of marine invertebrates), bacterial endosymbionts of nematodes, and nematodes (the dominant meiofauna in sediments) all increased in fertilized relative to control plots. Co-occurrence analysis of the most abundant microorganisms found that positive relationships were stronger and more prevalent than negative relationships. These findings suggest that bottom-up rather than top-down selection and facilitation rather than competition are the dominant ecological forces structuring microbial communities in Bay of Fundy mudflats.

Population Genomic Analysis Of The Atlantic Sea Cucumber (*Cucumaria frondosa*) From Atlantic Canada To Iceland

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The Atlantic Sea Cucumber (*Cucumaria frondosa*) is a commercially harvested lecithotrophic holothurian with a range spanning the North Atlantic and Arctic Oceans. It has a long dispersive larval stage which is distributed by ocean currents. To date, only COI sequence data has been examined for this species in the North Atlantic, which may lack the resolution to detect higher resolution structuring in this species, and sampling in Nova Scotia specifically was sparse (n = 14). To examine higher resolution structure through Atlantic Canada and Iceland, Restriction Site-Associated DNA Sequencing (RADseq) was used to generate RAD genomic libraries for 74 sea cucumber samples from four locations in Atlantic Canada and one in Iceland. RAD libraries were demultiplexed and loci were assembled using the STACKS denovo_map.pl

pipeline. Loci were then filtered for minimum mean coverage, maximum missing data, and minimum Minor Allele Frequency (MAF) using VCFTools. Filtered loci were analyzed for Fst using the populations program in STACKS, clustering analysis was performed in STRUCTURE, and BayeScan was used to identify loci potentially under selection. Overall, Fst was higher across loci for Iceland relative to sites in Atlantic Canada, clustering analysis additionally supports the hypothesis of Iceland forming a genetically distinct population, and six loci were identified as potentially under selection. There is also evidence of potential sub-structuring in Atlantic Canada.

3.6 Nature-Based Solutions

Chair: Fraser Clark

Assessing *Sporobolus* Arbuscular Mycorrhizal Colonization And Rhizosphere Carbon Stocks Across A Salt Marsh Chronosequence In The Bay of Fundy, Nova Scotia

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Salt marshes are blue carbon ecosystems that accumulate and store high amounts of carbon. The increasing loss of these ecosystems reduces global carbon storage capacity and climate change mitigation abilities. Carbon is accumulated through suspended sediment and autochthonous sources within the salt marsh, which may be utilized by salt marsh vegetation and fungal associates. Recent studies found that beneficial arbuscular mycorrhizal fungi (AMF) form associations with salt marsh plant roots. AMF receive fixed carbon from their host plant, and in return, provide the plant with mineral nutrients and an increased surface area, which leads to greater below ground carbon storage. We are investigating the role of AMF in carbon sequestration. We assessed AMF in dominant salt marsh plant species (*Sporobolus*), from low to upper high elevations at sites fringing the Bay of Fundy, Nova Scotia, and examined the correlation between organic carbon and AMF colonization. Additionally, we are analyzing mycorrhizal contribution to belowground carbon storage. We compared a chronosequence of restored marshes to reference salt marshes, by collecting sediment cores at each site over multiple years. Preliminary results show high AMF colonization rates (94%) and organic carbon densities (>0.045 g·C·cm-3) in *Sporobolus michauxianus* roots at older restoration and reference sites. This research will fill many knowledge gaps on the role of beneficial below ground fungi in salt marshes and their contribution to carbon accumulation and storage. Fungal influence on carbon storage as well as the importance of carbon sequestration in salt marshes are novel areas of research in Atlantic Canada.

Carbon Stocks And Loss On Ignition (LOI): Are We Misestimating Blue Carbon In Salt Marshes?

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Blue carbon has been quantified in salt marshes all around the world for the last couple of decades, but protocols used to estimate carbon stocks vary significantly between regions and research groups. Some studies have investigated these methodologies (LOI and organic carbon equations) and have found significant under- or overestimations of organic carbon. LOI in itself has been associated with numerous errors based on sample size, exposure time and temperature, and position in the muffle furnace. Applying this method to mixed sediment or predominantly clay-based sediment holds other challenges. For example, one lab in Texas found an overestimation of organic matter by 30-300% in clay-based soils. Two specific problems arise when conducting LOI on salt marsh sediments: 1) selecting a temperature that doesn't combust inorganic carbonates alongside organic carbon, and 2) clay contains structural water that isn't removed upon initial drying. The sample requires combustion using a lower temperature in the muffle furnace but using a temperature that is too low can result in incomplete ashing of organic matter. This presentation discusses the current literature on the topic, alternatives, a case study, and where we go from here. Interest in understanding the dynamics of how much blue carbon is stored in salt marshes has been increasing, and thus determining an accurate method to estimate organic carbon should be prioritized.

Fate Of Calcium Carbonate In Drained Salt Marsh Soils

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Salt marshes sequester large amounts of blue carbon, i.e., organic carbon (Corg), in their soils. However, these sediments also contain calcium carbonate ($CaCO_3$) contributed by calcifying organisms such as crabs, molluscs and foraminifera, whose shells are buried in the soils as they accumulate. Extensive areas of salt marsh have been drained on both the Bay of Fundy and much later on the St. Lawrence River estuary. It is recognized that drainage causes mineralization of the large stocks of Corg, adding to the burden of atmospheric CO_2. However, there is a potential for drainage to result in the dissolution of $CaCO_3$ - a process that takes up CO_2. The complete dissolution of $CaCO_3$ results in the uptake of 0.6 moles of CO_2 per mole of $CaCO_3$ dissolved. Thus, $CaCO_3$ dissolution in dykeland soils could partially offset the CO_2 emissions caused by mineralization of the Corg. This possibility that has yet to be investigated and there is a potential for continued $CaCO_3$ dissolution to continue as the depth of drainage in marsh deposits increases over time. We examine the possible magnitude of $CaCO_3$ dissolution as a CO_2 sink by comparing the $CaCO_3$ content in soils from undisturbed salt marshes to those drained for agriculture on the St. Lawrence River estuary.

The Tides They Came A Crashing: Tidal Flow Returns To Onslow-North River Dykeland

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The Onslow-North River managed dyke realignment and tidal wetland restoration project has been a collaborative, innovative initiative between the Departments of NS Public Works, NS Department of Agriculture, NS Environment, CBWES Inc. and Saint Mary's University. After more than 5 years of planning and preparation, full tidal exchange was restored in early November 2021 during the highest tides of the year setting the stage for the restoration of 90 Ha of tidal wetland habitat. Spatial patterns of sedimentation, sediment flux and water levels were measured throughout the site over 5 tides, including low altitude aerial imagery and video. Landforming had a significant impact on spatial patterns of sedimentation and drainage of the marsh surface with very high deposition in flooded dale areas (~4 cm per tide) and less on the crests. As expected, the inlet channel openings responded very strongly to the forces of the tidal bore, re-working material and setting the stage for establishment of an equilibrium form. Velocities and water levels measured in the field will be compared to modeled results using Delft3D. In light of all findings and experience at other managed realignment sites in the region, the anticipated restoration trajectory will be discussed.

3.7 Parasites

Chair: Fraser Clark

Effects Of Helminth Infection On European Green Crab (*Carcinus maenas*) And Atlantic Rock Crab (*Cancer irroratus*) Behaviour

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Atlantic rock (*Cancer irroratus*) and European green (*Carcinus maenas*) crabs are found throughout the Canadian Maritimes. Both are susceptible to helminth infection; the marine horsehair worm *Nectonema agile* infects the rock crab and the acanthocephalan *Profilicollis botulus* parasitizes the European green crab. Despite the discovery of these parasites decades ago, the effects they have on host behaviour is unknown. In the current studies naturally infected rock and green crabs were tested for predator evasion and aggression behaviour. European green crabs were additionally tested for their behaviour in an open field test. Rock crabs: no significant difference in predator evasion and aggression behaviour

between infection statuses, however parasitized did significantly increase speed during the aggression test. European green crabs: no significant difference in predator evasion, aggression, and open-field behaviours between infection statuses. A follow-up study investigating behavioural effects and the timing of these effects in experimentally infected green crabs looked at predator evasion and aggression behaviours, as well as righting responses in parasitized hosts. While no significant differences in predator evasion and aggression behaviour were seen in this study, speed and distance travelled were significantly decreased in parasitized crabs and they righted themselves significantly faster at 16 weeks of infection in comparison to unparasitized. These behaviour effects have implications for important stages in these helminths' lifecycles and reinforce the need for subsequent studies on behaviour manipulation in parasitized hosts.

Autofluorescence Application For Integrative Diagnostics And Elucidating Developmental Process Of The Swimbladder Nematode *Anguillicola crassus* In American Eels (*Anguilla rostrata*)

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Anguillicola crassus is an invasive parasitic nematode that currently infects the swimbladder of ~90% of American eels (*Anguilla rostrata*) in the Wolastoq | St. John River system in New Brunswick. The swimbladder is essential for regulation of buoyancy for eels. It is hypothesized that huge declines in American eel populations are attributed in part to *A. crassus* infection (COSEWIC 2012), with swimbladder damage impairing their survival and/or migration to the Sargasso Sea for reproduction. A. crassus larvae (L2) are released with eel feces and must be ingested by a copepod intermediate host to develop to L3. Trophic transmission to eels occurs by their ingestion of infected copepods, or fishes (i.e., paratenic hosts) that previously ingested infected copepods. Five species of parasites comprise the genus *Anguillicola*. Whereas they can be reportedly differentiated based on morphometrics of the buccal capsule and number of circumoral teeth in adult parasites, this is based on examination of only 2-13 individuals for four of these five parasite species. My project employed a paired analysis of 92 individual *A. crassus* parasites to assess both morphometrics of the buccal capsule and partial DNA sequence from 28S rDNA. Buccal capsule morphometrics are compatible with previous reports for A. crassus. DNA sequence data was invariant with 100% nucleotide identity with *A. crassus* partial 28S rDNA sequence from GenBank. Finally, we discovered that the buccal capsule and circumoral teeth of adult *A. crassus* are autofluorescent, as is a unique V-shaped sclerotized structure that occurs in L3 and L4, with highest excitation/emission of these ornamentations at 564nm/700nm. Autofluorescence of these unique structures/ornamentations offers an important diagnostic tool for distinguishing *Anguillicola spp*. parasites from the numerous other parasitic nematodes that infect copepods, Anguillid eels, and other fishes. Definitive species-level diagnosis of these parasites currently requires detailed morphometric analyses and/or sequencing of partial 28S rDNA.

3.8 Isotopic Advances in Marine Ecology

Chair: TBD

Interspecific And Intraspecific Resource Use And Partitioning Among Fish In Freshwater Tidal Zones

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Aquatic food-webs are continuous across the marine-freshwater interface, supporting cross-habitat movement of energy and nutrients. The freshwater tidal zone is the upstream limit of tidal motion in freshwater where riverine and marine food-webs overlap. Tidal rivers experience dynamic shifts in resource availability, which can stimulate complex food-web interactions. These conditions can promote individual specialization, where individuals within a population have unique resource use profiles distinct from other members of the population. Such populations may be considered more adaptable to change, and potentially more stable. Yet, the question of how marine and freshwater resources are assimilated by consumers in this complex region remains largely unexplored. This study aims to characterize freshwater tidal food webs and determine whether spatiotemporal variability in the availability of marine and freshwater resources underlies inter and intra-specific differences in fish foraging. I will assess the resource use of 16 fish species from the freshwater tidal zone of the Miramichi River (New Brunswick, Canada) using stable isotope ratios of carbon ($\delta^{13}C$), nitrogen ($\delta^{15}N$), and sulfur ($\delta^{34}S$) from liver and muscle tissue. I will investigate whether length and weight contribute to the observed differences, examining size as a potential driver of resource partitioning within species. Here, I will present preliminary resource use and isotopic niche width data.

Linking Declining Atlantic Salmon (*Salmo salar*) Populations With Multidecadal Changes In Their Marine Foraging Ecology

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Atlantic salmon (*Salmo salar*) populations have declined considerably over the last 50 years to the point where many populations are now threatened or endangered. This decline is believed to be largely attributed to low marine survival caused (in part) by changes in ocean temperature and prey abundance. To date however, research has focused heavily on the freshwater portion of the Atlantic salmon lifecycle, while the link between changes in the marine environment and Atlantic salmon growth, diet, and distribution at sea remains unknown. Studying migratory species in a marine environment is challenging as direct observations are difficult to make, and the setting is spatially complex. Bulk stable isotope analysis and compound-specific isotope analysis present a cost-effective alternative to traditional tagging studies as a consumers' isotope ratios reflect both its trophic position and the

different trophic pathways through which it assimilates energy and mass. Coupling stable isotope analysis with archived Atlantic salmon scales provides an opportunity to investigate Atlantic salmon marine ecology over a large time scale. This study aims to detail long-term trends in Atlantic salmon marine resource use, trophic position, and foraging locations of salmon caught returning to Bay of Fundy rivers and in the Northwest Atlantic Ocean and characterize how marine primary production pathways that support these salmon populations has changed through time. Here, I will present preliminary bulk and compound-specific carbon and nitrogen stable isotope analysis of Atlantic salmon caught feeding off the west coast of Greenland from 1968-2017.

Stable Isotope Analysis Of Baleen From North Atlantic Right Whale (*Eubalaena glacialis*) Reflects Distribution Shift To The Gulf Of St. Lawrence

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The endangered North Atlantic right whale's (*Eubalaena glacialis*) seasonal migration along the eastern seaboard of North America has been well studied. Since 2010, however, sighting data suggests that right whales have been traveling farther north to the Gulf of St. Lawrence. There is a need to better understand right whale distribution so we can manage these areas. Stable isotope ratios of Mysticeti whale baleen plates can provide details about an individual's migration and foraging behaviour over a period of several years. We examined whether stable isotope ratios of baleen could detect the right whale distribution shift, as well as measure variation within and between individuals. $\delta^{13}C$ and $\delta^{15}N$ levels were compared between eight right whales that died in 1992-2005 (pre-2010) and five right whales that died in 2019 (post-2010). We observed a change in both isotope ratios between the pre- and post-2010 groups, whereby the pre-2010 whales were depleted in ^{13}C and ^{15}N relative to the post-2010 whales (pre-2010 values = -0.5±0.1, and -0.9±0.2, respectively). These results suggest that the range shift observed in sighting data is also reflected in the isotope ratios of right whale baleen. Detecting shifts in right whale migration is essential for protecting this species, and stable isotope analyses may be useful in future conservation efforts.

3.9 Physical Processes

Chair: TBD

Hydrological Shifts In The Main Nutrient Limiting Phytoplankton Biomass Along Oligotrophic Estuaries Of Northeastern New Brunswick

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Phytoplankton growth in freshwater environments is generally constrained by phosphorus (P) availability, while growth in coastal, saline environments is generally limited by nitrogen (N). "Hybrid" systems such as estuaries should thus display both types of algal biomass limitation: by phosphorus at upstream, freshwater sites, and by nitrogen at downstream, saline sites. The pattern has previously been observed, but only for heavily populated estuarine watersheds with N to P ratios influenced by wastewater discharges, and over distances that stretched over 100 km. Here, we examine P to N limitation shifts over smaller distances (5-14 km) in a set of coastal catchments with relatively low human occupation. Four coastal watersheds were sampled over three years, in spring and summer, each one at a freshwater upstream station and a brackish downstream station. We conducted bottle nutrient addition experiments during which in vivo chlorophyll a was monitored. Algal growth stimulation by P addition decreased from upstream to downstream stations, while the inverse pattern was observed for growth stimulation by nitrogen addition. Our results show that the shift between P limitation (upstream) and N limitation (downstream) can occur on much smaller spatial scales than previously reported. Furthermore, cold waters (<15°C), highly turbid waters (>25 NTU) and high zooplankton densities (10-100 ind./L) diminished the stimulatory effect of nutrient additions. Algal community composition differed between up- and downstream sites, despite some overlap. Results are further discussed in light of the potential influence of wastewater treatment plant effluents on eutrophication.

Topo-Bathymetric Lidar For River Mapping: Fish Passage/Habitat

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Topographic-bathymetric lidar (TB-lidar) systems typically utilize two lasers: a near infrared (NIR) laser for topographic data collection (land features and water surface) and a green laser for bathymetric data collection (seabed or river or lakebed). These systems generate high-resolution seamless digital elevation models (DEMs) that include land and submerged elevation and orthophotos. Shallow water TB-lidar systems produce high-density lidar points in water depths of 10s of centimeters to ca. 15 m depending on water clarity. River John was surveyed with TB-lidar in 2019 and the Stewiacke River was surveyed in 2021. In the ca of River John, water level sensors captured the river/coastal interaction of elevated water levels during with Hurricane Dorian in Sept. 2019 in River John. The TB-lidar sensor measures the elevation of the water surface as well as riverbed, thus allowing the river depth to be

calculated. The depth map can be inverted and used as a cost surface to calculate the least cost path along the river. This results in a path that preferentially moves from pool to pool along the riverbed. This path can in turn be used to generate a longitudinal profile to assess fish passage and habitat.

3.10 Ocean Literacy, Natural History, and Ecology

Chair: Peter Wells

Canadian Integrated Ocean Observing System Atlantic: Sharing, Discovering, And Accessing Ocean Data

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The Canadian Integrated Ocean Observing System (CIOOS) is a national online platform for sharing, discovering, and accessing ocean data in Canada. CIOOS is nationally consistent and regionally relevant, so integrated data is visible across Canada. As one of the three CIOOS Regional Associations, CIOOS Atlantic is focused on the integration of oceanographic data from the Atlantic seaboard, a region spanning from Labrador to the USA. CIOOS Atlantic is committed to the development of a data management and dissemination approach that meets the needs of the local oceanographic community, and contributes to global ocean observing initiatives. Our online platform provides access to physical, biogeochemical, biological, ecosystem, and cross-disciplinary essential ocean variables as identified by the Global Ocean Observing System (GOOS) based on their importance to research, feasibility to observe, and cost to collect. The CIOOS Atlantic platform now gives users access to 55 datasets. Join us to learn more about what is currently available, how to access essential ocean variable data through CIOOS Atlantic, and who has contributed to date.

Communication Of Scientific Information: Assessing Informal Communication Practices Of The Gulf Of Maine Council On The Marine Environment

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For over three decades, the Gulf of Maine Council on the Marine Environment (GOMC) has served “as a forum for the sharing and exchange of scientific information as a basis for management decisions” in the Gulf or Maine and Bay of Fundy. The Council has produced hundreds of publications and promoted informal communication through many meetings, workshops, and conferences. Previously, we completed analyses of the Council’s published output, but did not explicitly examine its informal communication activities. Informal communication has been shown to be important in environmental management in cross-border and cross-jurisdictional contexts. In the case of GOMC, the ongoing informal communications and information exchanges at the twice-yearly meetings of Council members

keep government staff informed about projects occurring in each jurisdiction. This informal communication can be transient, but it is more immediate and timely than the substantially validated information resources offered by formal studies and subsequent publications. In this presentation, we will review GOMC's information exchange practices, which have seen a decline in the number of publications over the past decade, but a continuation of informal communication. We will place this review in the context of recent research on informal communication strategies of environmental organizations, particularly organizations that fulfil a boundary function. We will give attention to who attends Council meetings, noting the organizations and jurisdictions that they represent and the types of information that are exchanged. In our analysis, we will outline the advantages and limitations of relying on informal communication practices, and, based on this analysis, suggest how GOMC could capitalize on the benefits of its informal communication activities.

Using Digital "Bycatch" To Advance Natural History In All Types Of Ecosystems

Paul **Manning**

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Many ecologists have lamented the decline of natural history emphasis in scientific research. Others have argued that this apparent decline is concurrent with a shift in *how* we think about natural history research, with the ongoing development of "next-generation natural history". This presentation will draw on multiple case studies, to explore how next-generation natural history (data collected and collated through the platform iNaturalist) can be used to advance scientific knowledge. In the first, I explain how crowd-sourced data can improve understanding of large-scale biotic changes across urban ecosystems. In the second, I show how natural history data can improve coverage of ecological interaction networks. In the third, I share how iNaturalist data can be leveraged for pedagogical purposes through building competencies in exploring and managing data. I share a simple framework for recording and sharing natural history data and argue that sharing "digital bycatch" can have wide-reaching benefits for advancing scientific knowledge.

The Fundy Orca And His History - Naturally

Guy **Melville**

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Little information exists for orcas in the western North Atlantic Ocean including the Gulf of Maine (GoM) (Fig. 1). Here I report on a single identifiable male orca, in good health, seen in the gulf every year over the decade 2008 – 2017. I base his portrayal on a synthesis using opportunistic observations, reported mainly by recreational and fishing viewers. Sightings by season peak in summer, similar to the distribution of *ad hoc* single orca sightings over 7 previous decades. The majority of the observations also occur in the eastern half of the gulf. Quantitative assessments indicate that he was born in the late

1990s, sexually mature by 2009 and at ~7.70 m (25.4 ft) long was maturing physically in 2017 (~9.1 m/30 ft in 2022) (Melville unpub.). Most often people refer to him as 'Old Thom' (or similar spelling), and other names less often.

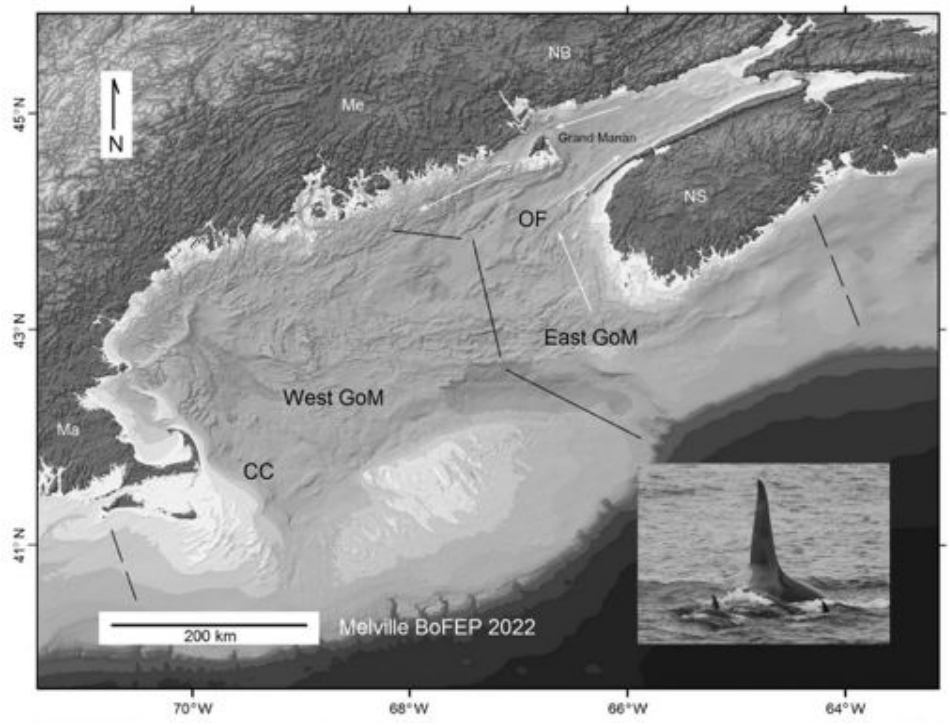

Figure 1. Terrain map of the greater Gulf of Maine (between dashed lines), the study system highlighting key regional seascapes and adjacent land jurisdictions. Ocean letter codes/symbols: CC = Cape Cod sub region, OF = Outer Fundy sub region; dark lines = separation of the West and East areas in this study (loosely approximates USA-Canada international boundary and division of major fishing zones); light arrows = major OF surface currents. Land letter codes, states/provinces: NS = Nova Scotia, NB = New Brunswick, Me = Maine, Ma = Massachusetts. Inset photo, foraging with dolphins, credit S. Lonergan.

The orca appears to subsist largely on small schooling fish in the gulf. He often feeds with white-sided dolphins (*Lagenorhynchus acutus*), and foraged with them on about 25% of sighting days. The focus: Atlantic herring (*Clupea harengus*) (primary?), Atlantic mackerel (*Scomber scombrus*), juvenile Atlantic pollock (*Pollachius virens*) and perhaps sand lance (*Ammodytes* sp.). For example, the dolphins eat herring as small as ~7.5 cm long (age 1; but usually > 18 cm, age ≥ 2). On one occasion a captain saw juvenile pollock leaping clear of the orca as it approached at short range. In addition, he has been observed depredating Atlantic halibut (*Hippoglossus hippoglossus*) caught on commercial fishing hooks and ingesting unidentified 'discarded' bait-fish. There are no reports of the capture or ingestion of free-swimming fish.

Accounts of potential prey proximal to the orca are consistent with limited historical information. Two examples are known, a single orca with herring in its mouth in the eastern gulf and earlier, the same orca "feeding" on mackerel. Observations of its lower jaw indicated worn teeth, to about half their normal height, interpreted as the consequence of contact between upper and lower teeth when eating such small food parcels. Other examples include single orcas in areas with schools of large herring,

bluefish and unidentified fish species. Orca diets may at times also include squid, supported by historical associations of orcas with pilot whales. A similar suite of small schooling species (hake replacing mackerel) would constitute the prey of the white-sided dolphins, with our understanding of their diets consisting of, like that of the orca a relatively small sample of observations. Current literature indicates both species probably benefit from the foraging association, modulated by foraging depths in relation to depths of the water column.

Observations indicate a general correspondence between the hunting behaviors of the orca and dolphins and variation in immediate dolphin abundance. Large numbers of dolphins participated in joint pursuit-capture events at the surface (n = 3 d, only 1 d^{-1}), for example, swimming with substantial speed in a band roughly perpendicular to the direction of travel. The orca swam with them, embedded in the band, usually with the largest dolphins proximal but to the side, and other dolphins scattered around but more so on the sides and behind (Fig. 2). Some dolphins swam in front of the orca, tending to cut across his direction of travel, although this occurred more during somewhat leisurely non-pursuit events. The dolphins alternated between longer periods of submergence and short bouts of porpoising. The bull could be seen much of the time, at or very near (his image or shadow) the surface on these occasions (hereafter fish 'drives') which lasted 30 s or more.

Figure 2. An example of the spacing of the orca and dolphins in a joint prey pursuit-capture 'drive'. Closest dolphins to the viewer lower right, furthest upper left, with two medium-large dolphins under water ahead and to the left of the orca. One large dolphin on either side of the orca's head. Other dolphins trailing, not shown. Female with calf out of picture, well behind at right. Telephoto credit: J. Melville.

Less pronounced, tail hits on the water occurred with varying intensity ('tap' - least, 'strike' - most) more often than drives (n = 8 d), sometimes with dolphins present but not on other occasions. Also precursors to dives, periods of submergence varied between those of fish drives and breaches, and tended to be part of longer mixed-behavior sequences (kinematic scales, 10 – 100 m, minutes) incorporating changes in speed and direction (including circuitous elements). When dolphins were present, they often remained submerged for longer periods as well. When both species emerged simultaneously some

dolphins would at times turn (obtuse angles) towards the orca, including his head, at slow speeds and from very short distances. With lags in emergence, a few of the largest dolphins would aggregate at the exact spots where the orca would eventually surface, milling about at least 20 s prior to his arrival.

Full breaches at various angles were also seen (n = 3 d), but with at most only a few dolphins "in the area". Each breach appeared to represent a precursor to a long dive, lasting at least 4 to 5 minutes. At surfacing, there were no dolphins proximal to the point of emergence. All breaches were seen in deeper waters (most ~ 200 m) and at a range of distances from boats.

The herring prey-base has become highly unstable in the last few decades, with recovery from previous collapse in the western GoM (Fig. 1) arrested and decline accelerating in the east; the cause – continued overexploitation across the gulf (*e.g.* Melville 2013). The patterns highlight problems of ecological resilience in the GoM, a complex predator-prey system. Residual herring remain in a precarious position, given the multi decadal over-fishing, elimination of reproductive age classes, and major historical losses of spawning grounds to salmonid net-pen aquaculture. Other key GoM predators have also felt the brunt of the human assault on herring. After 2000, productivity in the iconic puffin (*Fratercula arctica*, an alcid diver) declined at Machias Seal Island off Maine (eastern GoM), with the loss of juvenile herring as the principal food source (Diamond and Devlin 2003; see also Kress *et al*. 2016). The common tern (*Sterna hirundo*), a surface feeder has been negatively affected by juvenile herring declines in the same area (Scopel *et al.* 2018). Since the mid 2010s, unexplained near-shore deaths of humpback and minke whales have increased dramatically as herring landings dwindled in and contiguous with the GoM region (Melville 2018); the mortalities are probably the result of starvation, ultimately because of herring over-fishing. Many large bluefin tuna (*Thunnus thynnus*) (Turcotte *et al*. 2021) may now bypass the GoM altogether during the warm seasons in their search for larger herring.

Observations of this orca present a rare opportunity to learn more about a high-profile species in the NW Atlantic Ocean. While not an indicator of desirable ecosystem qualities, he certainly indicates in a clarion way (Editors 2004) the status of ecological health in the pelagic GoM .

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The Rise Of *Fucus serratus*: A European Invader Replaces Kelp And Irish Moss As A Canopy Species On Some Nova Scotian Shores

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The brown seaweed *Fucus serratus* arrived in eastern Canada in the mid 19th century from western Europe. It has become widely distributed on subtidal shores of the southern Gulf of St. Lawrence of Nova Scotia, Prince Edward Island, and New Brunswick. Over the last 50 years *F. serratus* established intertidal populations at several sites on the Atlantic coast of Nova Scotia. Here we describe the impact of this encroachment on the seaweed community of the low intertidal zone, historically dominated with a canopy of *Chondrus crispus*, and the shallow subtidal zone historically dominated by canopies of the kelp species *Laminaria digitata, Sacharrina latissima* and *Alaria esculenta*. On many intertidal and subtidal shores, *F. serratus* has become the dominant canopy species, leaving *C. crispus* as an understory species and shallow waters devoid of kelp. We hypothesize that the increasing populations of the invader may have been associated with the overharvesting of Irish moss during the 1960s and 1970s, and, more recently, with climate change and the large-scale harvesting of *Ascophyllum nodosum* in southwestern Nova Scotia.

Indicators Of Ecosystem Adaptation For The Bras D'or Lake Biosphere Reserve

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The Bras d'Or Lake ecosystem of Cape Breton Island (a UNESCO Man-and-the-Biosphere Reserve) is a complex estuary of 33 km^3 volume with a 3,600 km^2 watershed. It was flooded by the Atlantic Ocean about 6,000y BP. The habitats and secondary production of this ecosystem has supported humans since the last deglaciation. By 2016, the human population had declined to barely 33,000 residents (median age of 45.5y). The commercial fisheries are gone, tourism is the last industry, and the Climate Change is upon us. A First Nations-led Collaborative Environmental Planning Initiative recognizes that maintaining the health of the ecosystem is essential to adaptation, and strives to plan accordingly. Selecting an indicator set for this Biosphere is challenging because of its complexity and limited monitoring history. Firstly, environmental, ecological, economic and social processes (e.g. shoreline erosion, primary production, sustainable tourism, citizen science) are prioritized on criteria of their sensitivity to known forces of change (e.g. climate change, ecological invasions, resource exploitation, land use) and the existence and feasibility of ongoing time series of relevant measurements. An initial indicator set is used

to chart historical change and inform future modes of adaptation. This mesotrophic estuary has maintained species diversity, improved in water quality and declined in secondary production since the last century. Water temperature and Secchi depths are increasing, oxygen concentration and ice cover are declining. Species invasions and shoreline hardening are expanding, along with coastal land development, aquaculture and recreational fishing. Adaptive planning and management is impossible without ongoing monitoring of indicators of ecosystem health.

4. Poster Abstracts

Assessing The Ecological Integrity And Ecomorphodynamics Of Coastal Habitats Created Using Nature-Based Techniques (Sand Engines And Living Shorelines) In A Canadian Context

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Coastal ecosystems are shaped by ecomorphodynamic processes that influence their capacity to protect the mainland against erosion and flooding, and provide habitat for species of conservation and/or commercial value. However, climate change and habitat loss threaten these ecosystems and their functionality. “Building with Nature” solutions, including the construction of sand engines and marsh sills with living shorelines, have been used to restore coastal ecosystems, but neither has been trialed in areas subject to harsh winter conditions. A Piping Plover habitat compensation project currently underway at a barrier spit near Shippagan, New Brunswick is piloting both techniques in Atlantic Canada, with the intent of restoring degraded sandy beach, sand dune, and salt marsh habitats. The proposed research seeks to address knowledge gaps surrounding a) the feasibility of employing these restoration techniques in cold climate regions and their ecomorphodynamic and ecological impacts, and b) whether habitats restored using such techniques are ecologically comparable to their natural counterparts. A longitudinal study will analyse how restored habitats change seasonally and over time, while two comparative studies will assess how the restored beach-dune system and the restored marsh compare with nearby naturally occurring ones. Geospatial, environmental, and ecological data, collected seasonally, will be examined through an ecological integrity lens: Analyses of biodiversity, geomorphology, and food web dynamics will be used to assess the composition, structure, and function, respectively, of the restored habitats. These results will improve our understanding of how restoration methods influence barrier-spit ecosystems in cold climates, and how cold climates influence restoration outcomes.

Methylmercury Bioaccumulation In Coastal Invertebrates In The Minas Basin, Bay Of Fundy

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Methylmercury (MeHg) is a neurotoxin produced in estuarine sediments that bioaccumulates and biomagnifies in ecosystems and has negative impacts on organism health. Studies on MeHg bioaccumulation in coastal invertebrates at the base of the food web in Eastern Canada are limited, and this data is necessary to determine risk for bioaccumulation in higher trophic level organisms like fish and migratory birds. Specifically, the Minas Basin in the Upper Bay of Fundy provides critical habitat for fish spawning, and is an important stopover site for over 30 species of shorebirds during their southern migration. Fourteen families of invertebrates were collected from 5 sites in the Minas Basin during summer 2021, and analysed for concentrations of MeHg and THg, and stable isotopes of $\delta^{15}N$ and $\delta^{13}C$. Sites varied significantly in sediment THg (ANOVA $p < 0.001$), with mean concentrations ranging from 2.01 ng/g to 25.56 ng/g (dw). No clear relationship was seen between sediment THg and invertebrate THg or MeHg. Most invertebrate families had concentrations of MeHg below the Canadian tissue residue guideline for the protection of wildlife consumers of aquatic biota of 33 ng/g, but polychaete families (Goniadidae, Maldanidae, and Phyllodocidae) and mud snails (Nassaridae) had some individuals with MeHg levels above this guideline. Relative trophic position of invertebrates was determined using $\delta^{15}N$, and mean $\delta^{15}N$ for families ranged from 6.72 (Corophiidae) to 14.14 (Goniadidae). A positive correlation was seen between MeHg levels and $\delta^{15}N$ in invertebrate families, consistent with the bioaccumulative nature of MeHg in the food web.

The Influence Of Sediment Geochemistry On Methylmercury Bioaccumulation In Coastal Invertebrates In The Minas Basin, Bay Of Fundy

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Methylmercury (MeHg) is a toxic contaminant that readily bioaccumulates and biomagnifies in food webs, and negatively affects organism and ecosystem health. Impacts on ecosystem health from MeHg have been extensively studied in freshwater ecosystems however much less is known about MeHg retention and biomagnification in coastal ecosystems. Intertidal invertebrates are abundant in estuaries and are critical prey sources for migratory birds and marine fish, and thus determining the uptake of MeHg by intertidal invertebrates is essential for determining MeHg exposure in higher trophic levels. To assess the effects of sediment geochemistry on MeHg bioavailability to invertebrates, organism MeHg concentrations were compared to total organic carbon (TOC), sulfur speciation, and mercury speciation in pore water and sediment. We found that bioaccumulation of MeHg in invertebrates was not influenced by total mercury levels in sediments, or sulfate concentrations in pore water. However, a positive correlation between sediment total carbon content (measured as % Loss on Ignition) and total mercury was found. This research provides quantitative data on MeHg bioavailability in the Minas Basin which can be used to protect both ecosystem and human health. By identifying areas that are at greater

risk for increased MeHg production this research sheds new insight on the health of ecosystems critical to migratory birds, coastal fisheries, and many industries in Atlantic Canada.

Implementation Of Marine Spatial Planning In Atlantic Canada: Considering A Role For Municipal Governments

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The first-generation Marine Spatial Plan for the Scotian Shelf-Bay of Fundy will be completed by March 2024. Marine Spatial Planning (MSP) is mostly an activity initiated and managed by senior levels of governments. Coastal communities will be impacted by decisions about marine management, but due to lack of jurisdiction in marine spaces coastal municipalities are usually not involved, even though they could provide local knowledge and planning protocols that could support planning in the marine environment. This poster reports on a study that explored the role for municipalities in MSP in Nova Scotia. Interviews were conducted with participants from government and non-governmental organizations. While the views about the purpose and processes of MSP varied, all participants saw the need for input from every level of government. The results suggest that knowledge of MSP and understanding of a municipal government role is limited. The participants were skeptical about what senior government understands about municipal governments' planning capabilities and what they could offer to MSP processes. If MSP is intended to facilitate sustainable marine management while promoting a blue economy, coastal communities should be primary beneficiaries. Coastal communities occupy the land-sea interface; yet, as many interviewees pointed out, the land and sea are often separated in planning processes. This poster will suggest how MSP in the Nova Scotia context can include local government in marine sector decision-making, leading to marine plans with local relevance and connection across planning systems.

Concentration Of Potential Microplastics In Soft-Shell Clams (*Mya arenaria*) Is Size Dependent

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Microplastics (MP) are a widespread pollutant in the marine environment. These contaminants are found in benthic organisms, including the soft-shelled clam (*Mya arenaria*), an ecologically and economically important filter-feeding bivalve. This study aimed to quantify the relationship between concentration of potential MP and clam size (mm and mean tissue weight). Since filtration rates are thought to effect MP ingestion in bivalves, it is hypothesized that smaller individuals will possess a higher concentration of MP per gram of soft tissue due to their greater filtration rate. We also examined whether MP type was independent of juvenile size. Juvenile and adult *M. arenaria* were collected from Kouchibouguac, NB and digested in KOH to extract potential MP, which were identified under a dissecting microscope. Potential MP concentration had a significant non-linear relationship to M. arenaria size, with the highest concentrations (per g of soft tissue) in small juveniles. Potential MP type

was independent of juvenile size. 90% of potential MPs identified in this study were fibers and their concentration shared the same non-linear relationship to size (mm) as total potential MPs. Our results suggest that juvenile *M. arenaria* may be more vulnerable to any negative effects of MP ingestion than larger individuals.

Benthic Nutrients, Ph, And Infaunal Communities In Intertidal Soft Sediments

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Coastal ecosystems are dynamic, multi-stressor environments. Acidification on the coast is most often driven by eutrophication, by which increased nutrients promote primary productivity, resulting in decreased pH and oxygen. While research on water column acidification is ongoing, comparatively little is known about how acidification occurs within intertidal sediment and how it affects infaunal invertebrates, especially from a multi-stressor perspective. The data presented here are part of an effort to build a descriptive dataset of sediment characteristics, chemistry, and infaunal community structure in intertidal soft sediments in New Brunswick. During Aug-Oct 2021, sediment samples were taken to measure pH, chlorophyll-α concentration, nitrogen content, sediment characteristics, and the invertebrate community at sites in the Bay of Fundy and the Gulf of Saint Lawrence. Initial trends in sediment chemistry and the invertebrate community (species richness, abundance, production) will be described using univariate generalized linear modeling. This dataset will be expanded through continued sampling in summer 2022, including oxygen profiling and an organic enrichment experiment to measure the effects of eutrophication, acidification, and deoxygenation on benthic infaunal communities.

Comparison Of Salt Marsh Hydroperiods Between The Microtidal And Megatidal Ranges Of New Brunswick, Canada

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The influence of tidal range on salt marsh hydroperiod is not as well understood in regions that experience megatides (>8m amplitudes) compared to their micro-mesotidal (0-4m) counterparts. Hydroperiod is a major driver of wetland establishment and geographic variation in wetland processes. New Brunswick offers a unique opportunity to study and compare salt marshes with varying tidal ranges at relatively close geographic distances. To measure the frequency, duration, and depth of marsh platform flooding, water level loggers were deployed in the creeks of six marsh sites, split between the Northumberland Strait (microtides <2m) and the Bay of Fundy (megatides >8m). Analyses of data from 2020 showed that Northumberland Strait sites were consistently more flooded than the Bay of Fundy sites at both the seaward marsh edge and at the transition between the low (*Spartina alterniflora*) and high (*S. patens*) marsh zones. Specifically, Northumberland Strait sites spent up to 40% more time inundated at the edge and 20% more at the transition zone than Bay of Fundy sites. Our study is a first

step in understanding connectivity between salt pool and creek sub-habitats of salt marshes and the nearshore area, and marsh access to fish, in northern temperate latitudes of North America. Furthermore, it helps fill the gap in the literature of marsh dynamics in megatidal environments.

Situating Atlantic Canada in the global research on the science-policy interface and the oceans

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Occupying more than 90% of the habitable space on earth, the oceans are essential for the ecosystem, economic, social, and political sustainability of the planet. Immense pressures, e.g., over exploitation of marine resources, have placed marine environments at serious risk. Researchers, managers, and policy makers around the world are giving increasing attention to the complexity of factors contributing to the deterioration of the oceans, which is resulting in a growing body of literature about the intersection of research and policy about marine environments. Using a variety of databases we identified 368 research publications about the science-policy interface specifically related to the oceans published between 2018 and 2021. We then used the Web of Science to collect records of papers cited by or citing the 368 papers to determine that 9,760 other publications are linked in the global citation network. This poster will present an analysis of the network of these 9,760 papers to illustrate the global research landscape in which the ocean science-policy interface studies are situated. We will give particular attention to the different topics represented in the network, and the relative position that the science-policy interface research occupies. We will also outline the contribution of authors in the Atlantic Provinces, both in terms of the attention that the region has received as a research object or setting, and the contribution of Atlantic Canada researchers to global research understanding of ocean science and policy. In addition to these findings, the poster will identify research opportunities meriting attention.

Towards Comprehensive Coastal-Marine Policy: Comparison Of Integrated Coastal Zone Management And Marine Spatial Planning

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Coastal and marine ecosystems are closely linked by socioeconomic, biophysical, and geochemical processes. Therefore, coastal-marine spaces should be managed in an integrated way and recognize land-sea interactions. Today, two approaches dominate coastal-marine management. Integrated coastal zone management (ICZM) has been implemented in coastal planning (although not in Canada), while marine spatial planning (MSP) has been applied in marine systems (Canada has adopted MSP). ICZM is similar to MSP. Understanding the potential for synergies between the two requires a comprehensive analysis of their differences and linkages. Based on a literature review, this poster will outline the differences and similarities. The approaches differ in four aspects: 1. while a sectoral approach characterized the origin of ICZM, MSP roots are found in marine conservation and environmental zoning; 2. ICZM is process-oriented and emphasizes integration across agencies and sectors whereas

MSP seeks to allocate human activities in marine spaces effectively; 3. ICZM focuses on the coastal zone (nearshore waters to inland backshore), while MSP covers marine areas (mainly the territorial sea and Exclusive Economic Zone); and 4. ICZM is based on a local context and MSP area-based. On the other hand, linkages include: 1. a shared area of interest in the territorial sea; 2. provincial jurisdiction applies to both approaches; and 3. ICZM and MSP share principles such as stakeholder inclusion; and adaptive, holistic, ecosystem, and future-oriented approaches. Understanding the linkages and differences can contribute to cohesive coastal-marine policy and planning, benefiting both marine and coastal management, especially in Canada.

Comparing the provision of protective (wave energy dissipation, erosion prevention) and ecosystem services (habitat, primary productivity, blue carbon) of newly constructed marsh sill to a natural marsh

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The purpose of this research is to quantify the protective and ecosystem services of a natural marsh in the Acadian Peninsula. The natural marsh variables will be compared to those of a newly constructed marsh sill. My research will focus on assessing the effectiveness of a marsh sill (created using beneficial re-use of dredge material) in the provisioning of numerous co-benefits including habitat, biodiversity and erosion reduction. The impact of snow and ice on the integrity of the marsh sill will be assessed. Field research will be conducted on the Chiasson Spit, adjacent to the Shippagan Gully, located in New Brunswick. This is a habitat offsetting, or a conservation allowance proposed to mitigate the unavoidable alteration of Piping Plover Critical Habitat at the site. Wave energy dissipation will be measured using RBRduet³ T.D|wave16 — temperature and pressure sensors. Erosion reduction will be quantified upon carrying out repeat Remotely Piloted Aircraft System (RPAS) and measuring the erosion rate at the marsh edges. Field cameras will be mounted to record habitat use at both sites. Heat motion maps will be generated using a Python script to show where habitat use is optimum. The primary productivity will be calculated upon collecting aboveground biomass samples. Sediment cores will be taken by each vegetation plot. The results from the study are expected to indicate that the marsh sill with living shoreline exceeds natural marshes in every aspect. This research will provide empirical data which will be included in formulating engineering design standards for living shorelines.

Perspectives On Assessing Recovery Feasibility Of Inner Bay Of Fundy Atlantic Salmon *Salmo salar* 20 Years On

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Despite being the focus of significant recovery efforts under the Species At Risk Act (SARA) since 2003, the endangered Atlantic salmon of the inner Bay of Fundy (iBoF) have seen little improvement in abundance or rates of return. The Department of Fisheries and Oceans is “uncertain whether the overall

recovery goals and objectives […] remain relevant and achievable" for the population (DFO, 2021). Setting relevant and measurable recovery goals is an important component of overall success for endangered species management. In the context of SARA, the process of determining the feasibility of recovery for a species plays a significant role in shaping short- and long-term recovery goals for a species. Relatively little research has been done on the feasibility determination process. However, the 2021 SARA policy on survival and recovery outlines new guidelines on determining recovery feasibility, providing an opportunity to examine this under-studied process and gain insights on how recovery goals are set under the Act. My research explores recovery feasibility determination in the case of iBoF salmon, through a qualitative analysis of government reports and documentation on recovery planning efforts for the species, as well as interviews with current and past members of the iBoF Salmon Recovery Team. In this poster, I will identify key themes associated with recovery feasibility and its determination along with the barriers and enablers to assessing feasibility, with the goal of characterizing how perspectives on the topic have changed over time.

Examining Export And Bioaccumulation Of Methyl Mercury In A Bog Habitat Impacted By Herring Gull Guano And Water Table Restoration On Brier Island, Digby County, Nova Scotia

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Big Meadow Bog (Brier Island, NS) underwent water table restoration which was completed in the summer of 2018. The bog is also host to 4000-6000 herring gulls clustered in a small area in the Northern Bog that feed at nearby mink farming and aquaculture sites. An examination of water quality and lower trophic level biota was initiated to set a baseline for methylmercury concentrations in the food web. Outflow water samples showed a seasonal trend between 2018-2021 with highest concentrations and % MeHg occurring during the summer period for 2019 and remaining lower for 2020-2021 data. The % MeHg increases to >60% in July of 2019 and reduces to <40% in the following years. Similar patterns were observed in DOC (mid summer highs of 40-60 ppm DOC) and total phosphorus (0.5-2 mg/L) with a large portion present as orthophosphate. A survey of invertebrate bioindicators of mercury bioaccumulation in the food web indicated a wide range in concentrations (~0.06 - 1778 ng/g MeHg dry weight). Highest median MeHg concentrations were observed in water striders, water boatmen, milky backswimmers. Other invertebrates also showed high maximum MeHg concentrations in some individuals such as ground beetles (max 721 ng/g), midges (705 ng/g), spiders (1779 ng/g) and predaceous diving beetles (1074 ng/g). An examination of MeHg versus THg results for a subset of samples shows 4 – 133% of the THg is present in a MeHg form. The top 3 families for MeHg content (Corixidae, Gerridae, Notonectidae) have >90% MeHg likely due to feeding ecology and specific habitat chemistry.

Assessing The Role Of Allochthonous Inputs In Restoring And Protecting Blue Carbon In Bay Of Fundy Salt Marshes

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Blue carbon is the organic carbon (OC) stored in coastal wetland ecosystems, including tidal salt marshes, mangroves, and seagrass meadows. Due to rapid accumulation of OC in restored salt marshes along the Bay of Fundy, they have been identified as potential carbon sinks; however, research shows that most OC accumulating in restored marshes is of allochthonous nature (i.e. derived from marine or terrestrial ecosystems). Differentiating between sources of OC in restoration sites is key for carbon accounting purposes as only in situ sequestration of carbon dioxide by salt marsh primary productivity (autochthonous OC) offsets greenhouse gas emissions. Because salt marshes also export large amounts of their fixed carbon, identifying the mechanisms that lead to long-term protection of stored OC is crucial to ensure these restored carbon sinks will have meaningful climatic impact. The Bay of Fundy provides a natural laboratory to study the role allochthonous inputs play in restoring and protecting blue carbon because of the broad range in suspended sediment supply and tidal flooding. This project aims to 1) measure the contribution of allochthonous and autochthonous OC in natural and restored salt marshes and 2) investigate the function other allochthonous inputs (e.g. mineral sediments) provide in protecting stored OC from decomposition. These objectives will be explored over spatial (e.g. low vs. high marsh, upper vs. outer bay) and temporal scales (i.e. chronosequence) so the resulting data can be used to develop a predictive tool for evaluating the blue carbon potential of future salt marsh restoration sites in the region.

Dynamics Of *Spartina patens* Patches In A Restoring Salt Marsh In Aulac, NB

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The grasses *Spartina alterniflora* and *Spartina patens* are foundational to the salt marsh community. To fully understand how vegetation colonizes an area that is restoring, the details of plant dynamics need to be quantified. This includes state of plants (live, dead, flowering, canopy height), rates of spread, and possible competitive interactions among plant species. Given that in 2021 our Aulac restoration project was in its 11th year post beaching of the old dike, we focused on *S. patens*, the dominating plant in the high marsh zone of established marshes, to quantify how it is growing, and whether it has started to compete with *S. alterniflora* in the restoration site proper as well as along the new dike edges. Quadrats were placed in areas within and adjacent to the *S. patens* patches and key plant characteristics were monitored at ~2 week intervals during the growing seasons of 2013-2021. Although initial colonization of *S. patens* patches was early in the project, their spread has become measurable only in recent years. In 2021, we found a significant difference in all key characteristics for the different *S. pat*ens patches. Live stem density was higher in dike patches than in site proper patches. Dike patches in Restoration East encroached further and more consistently than those in the Restoration West. Evidence of

interspecific competition between the two species was present. Quantification of patterns and underlying processes in salt marsh restoration is important to understand successional stages and rates of restoration, and to plan for future restoration projects.

Onslow-North River Managed Dyke Realignment And Tidal Wetland Restoration Project

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The Onslow-North River managed dyke realignment and tidal wetland restoration project is a collaboration between the Nova Scotia government, researchers and industry. It has two main goals: to increase local flood resilience and to restore an important tidal wetland ecosystem. This poster will document the stages of project implementation since 2015 including marsh body consultation, design, modeling, earthworks, breach and public education. In October 2021, the existing dyke along the Salmon and North Rivers was breached with an excavator during neap tides at several key locations, allowing tidal waters from the river to return to the floodplain. In early November 2021 the first high Perigeen Spring Tides flooded the entire site up to the modelled boundary setting the stage of ultimate restoration of 90 ha of tidal wetland habitat. Ultimately this project will create fish and wildlife habitat and contribute to reducing flood risk in Truro, therefore enhancing local biodiversity and climate resilience. In addition, it provides an important case study and public demonstration site for additional large, complex dyke managed realignment projects in the Bay of Fundy.

Controls On Water Table Fluctuations In Two Salt Marshes On New Brunswick's Baie Des Chaleurs

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In order to preserve, restore or manage salt marshes, an understanding of their hydrological processes is critical. My research assesses the controls on water table fluctuations in Rivière du Nord and Daly Point salt marshes on New Brunswick's Baie des Chaleurs. Using data from pressure transducers logging water table levels at intervals of 15 min over the summers of 2018 and of 2019, we determined the impact of tidal channels on marsh soil water drainage. We have located studies on water table fluctuations in only four sites outside of Baie des Chaleurs. In Boston Harbor, soil water drainage occurred only 10 m from the channel. On the Yangtze estuary, soil water drainage was affected at a distance of at least 13 m away from the tidal channel. In Bay of Fundy marshes, the impact of the tidal channel was not found

beyond 15 m. Tidal channels on the Hudson River estuary seemed to influence salt marsh soil water drainage at a distance of 36 m from tidal channels. On Baie des Chaleurs, tidal channels had a greater impact on soil drainage, affecting water tables over a distance of at least 42 m at Rivière du Nord and 39 m at Daly Point. However, a multiple linear regression analysis, including sample site elevation the marsh and the year along with distance from channel, revealed that all parameters were statistically significant. These results suggest a difference in marsh soil characteristics and yearly sea level.

Fundy Brachiopods: Monitors Of Oceanographic Conditions Important To The Fisheries Industry

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Over the years, the world has undergone many changes as well as climatic ones, with changing ocean and atmospheric temperatures well documented since the late 1800s. Research into the affects of changing ocean temperature, salinity, and pH on oceanic life and, particularly, calcifying organisms is relatively new. The Bay of Fundy is host to many calcifying organisms, including brachiopods which construct their shells using layers of low-magnesium calcite which, when biomineralized, maintain the environmental conditions within its matrix. Of these environmental conditions, oxygen-18 and carbon-13 isotope ratios, as well as minor element levels, such as magnesium and strontium, are of particular note as they can be used as proxies to develop a paleo-timeline of past and current environmental conditions. With oxygen-18 and carbon-13 ratios, temperature and productivity levels within the water can be determined for the time span of the brachiopod. Magnesium levels within the calcite of the brachiopod shells have been observed to be influenced by temperature, growth effects, and carbonate chemistry, while strontium has been noted to be a potential proxy for dissolved inorganic carbon, allowing for the normalization of the carbonate chemistry. Thus, brachiopods may be inexpensive but important monitors of changing oceanographic conditions of special interest to the fisheries industry in the Bay of Fundy.

Effect Of Population Of Origin On Germination Success Of *Spartina alterniflora* Collected From The Bay Of Fundy And Northumberland Strait

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Saltwater cordgrass *Spartina alterniflora* is the bioengineer of salt marshes along the eastern North American coast, and is essential for salt marsh restoration. However at northern temperate latitudes, little is known about its reproductive biology. Our main objective was to evaluate germination success for different *S. alterniflora* populations in Maritime Canada. In September-October 2020-2021, we collected mature seeds (caryopses) (determined from a seed drop test) from 3–4 populations (sites) within each of the macrotidal Bay of Fundy and microtidal Northumberland Strait, and from parent plants of short- and tall-form phenotype. Following cold stratification (4 degree C, ~12wk, in freshwater or 40ppt saltwater), we germinated seeds under recommended diurnal thermoperiod conditions. For the 2020 collection, overall germination success was 19, 35, 45% (± 1% SE) on days 6, 14 and 30. In the

first week, Bay of Fundy seeds germinated earlier than Northumberland Strait seeds (26% vs 12% on day 6); following that, germination success was similar between regions. The different sites within regions accounted for ~20% of the random variation in germination success. Germination was not affected by phenotype (e.g., 36% for short-form vs 34% for tall-form on day 14). Rather, germination was most affected by seed storage treatment (e.g., 45% for freshwater vs 24% for saltwater, on day 14) and this effect persisted throughout the 30-day germination trial. We are conducting a second germination trial with seeds collected in 2021 to assess generality of results. Our research helps evaluate the strategy of using *S. alterniflora* seedlings for salt marsh restoration.

Effect Of The Snail *Melampus bidentatus* On The Decomposition Of Salt Marsh Grasse

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The common marsh snail *Melampus bidentatus*, found in salt marshes across eastern North America, is thought to be a detritivore. While recent studies have shown that the snail consumes both dead and live marsh grass (*Spartina patens* and *Spartina alterniflora*), few have examined its role in decomposition. Our objectives were to assess the effectiveness of using litterbags to study snail-grass interactions and to determine *M. bidentatus*' effect on decomposition by examining changes in marsh grass dry weight exposed to different snail densities. In summer 2021, we deployed 360 litterbags containing known amounts of dry grass and live snails in a randomized block design in a Northumberland Strait salt marsh. Each bag contained a treatment combination with one of six start and end dates (between July and September), three snail densities (0, low, high), two initial grass states (dead, live), and the two *Spartina* species. Throughout the experiment, snail survival and weight decreased over time, while changes in shell length were negligible. Despite this effect on snails, the percent loss of grass dry weight was greater (i) with increased density of live snails, (ii) for live grass than dead grass, and (iii) for *S. alterniflora* than *S. patens*. Although there is room to improve the litterbag method to increase snail survival, our results illustrate that *M. bidentatus* affects the breakdown of *Spartina* detritus in the salt marshes of Maritime Canada. Our study also contributes to improving the understanding of *M. bidentatus'* role in salt marsh decomposition processes, which are critical for nutrient recycling and ecosystem health.

Enhancing Ocean Literacy In The Fundy Community - Continued Activities Of BoFEP's OL Working Group

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A core part of BoFEP's mission is communication and education about environmental issues and challenges facing the Bay of Fundy. One of its working groups focuses on ocean literacy (OL), defined as

"understanding the ocean and our relationship to it". The WG has three objectives: (1) Identify the most appropriate ways to introduce the ocean/climate topic into the public school system; (2) Prepare a relevant bibliography; (3) Provide information, on an ongoing basis, to Bay of Fundy communities on the Bay's environment. To date, the WG has organized OL panels at two BoFEP workshops (2016, 2018) to discuss and report on this topic. The subject must be a high priority for the public at large and a responsibility of BoFEP's diverse membership, hence the current discussion panel of OL leaders at this conference. Next steps: (1) Assist the NS Department of Education in OL initiatives in public schools; (2) Identify appropriate age-appropriate ocean resource material suitable for teachers, with a supporting bibliography; (3) Engage relevant university Faculties of Education on how to include OL training in B.Ed. and M.Ed. degree programs, including short term courses; (4) Strengthen the linkage between OL and citizen science initiatives, given the value of learning by doing; and (5) Consider suggestions coming from the OL panel discussions at this years Conference. Members of the Fundy coastal community are invited to join the WG to participate directly in this vital quest to improve public and community understanding of the Fundy coastal and ocean environment.

Understanding Parameters For Site Characterization And Their Influence On Restoration Trajectory In Tidal Marshes In Nova Scotia, Canada

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Low-lying coastal ecosystems, such as tidal wetlands, are vulnerable to degradation or loss due to climate change and anthropogenic influences. Accelerated changes in vegetation distribution and pattern, vertical accretion, and erosion along the marsh edge have called into question the sustainability of these ecosystems into the future. There are few remaining untouched, natural tidal marshes in Nova Scotia therefore, ecosystem restoration has been a popular avenue for rehabilitating damaged marshes. Recent studies have attempted to characterize tidal marshes based on their conditions from measured variables. Further, there is a research gap surrounding the trajectory of restoring tidal marshes in Nova Scotia and whether site pre-conditions impact the restoration trajectory. We are investigating the characterization and trajectory of restoring and natural tidal marshes within Nova Scotia. We are assessing site similarities and differences based on abiotic variables, taking into consideration geomorphology, hydrology, sedimentation, elevation, vegetation, and carbon sequestration. We are exploring trajectory following characterization of natural and restoring marshes, considering site pre-conditions for restored marshes. We intend to analyze previously collected data in addition to re-measuring parameters such as Rod Surface Elevation Tables (RSETs), marker horizons (MH), sediment cores, vegetation surveys, and hydrological data, to create a present day baseline. The goal of our research is to provide a model which can aid in tidal marsh classification and help distinguish the trajectory of tidal marshes. Our classification and restoration trajectory data will allow for a better understanding of tidal marsh health and contribute to the improvement of restoration techniques.

5. 2022 Environmental Stewardship Award Winner – Jeff Ollerhead

In 2004 the Bay of Fundy Ecosystem Partnership created an award to recognize the significant efforts of individuals in promoting and advancing the environmental stewardship of the Bay of Fundy, reflecting the Mission Statement and Guiding Principles of BoFEP. BoFEP is proud and delighted to announce that the 2022 Environmental Stewardship Award will be presented at the ACCESS/BoFEP Conference in Truro, NS to **Dr. Jeff Ollerhead.**

Jeff is a professor in the Department of Environment and Geography at Mount Allison University who where he has worked for more than 25 years. He also served as Provost and Vice-President Academic and Research from 2016-2020.

As a coastal geomorphologist specializing in beaches and salt marshes, he has been particularly involved in designing and monitoring salt marsh restoration efforts in the upper Bay of Fundy. He has long been an advocate of maintaining and restoring salt marshes as natural shoreline protection features rather than simply armouring coasts with inflexible rock barriers. He worries that too much of New Brunswick might end up with fixed concrete retaining walls to hold the ocean back — something he refers to as the "New Jersey-fication" of the coastline.

Jeff, a staunch supporter of BoFEP almost since its inception, is unquestionably a worthy candidate for this special recognition and we in BoFEP extend our warm thanks to him for all his past and ongoing efforts on behalf of the Bay of Fundy and its unique and vulnerable ecosystems.

6. ACCESS Student Award Winners

Best Undergraduate Poster – Amanda Fenech, Huntsman (HMSC) Aquarium

Undergraduate Poster Honourable Mention – Meryem Upson, McGill

Best Graduate Oral – Emma Bowser, UNB Fredericton

Graduate Oral Honourable Mention – Stephanie Scott, UNB Fredericton

Best Graduate Poster – Mia Francis, UNB Saint John

Graduate Poster Honourable Mention – Simon-Luc Noël, Dalhousie University

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