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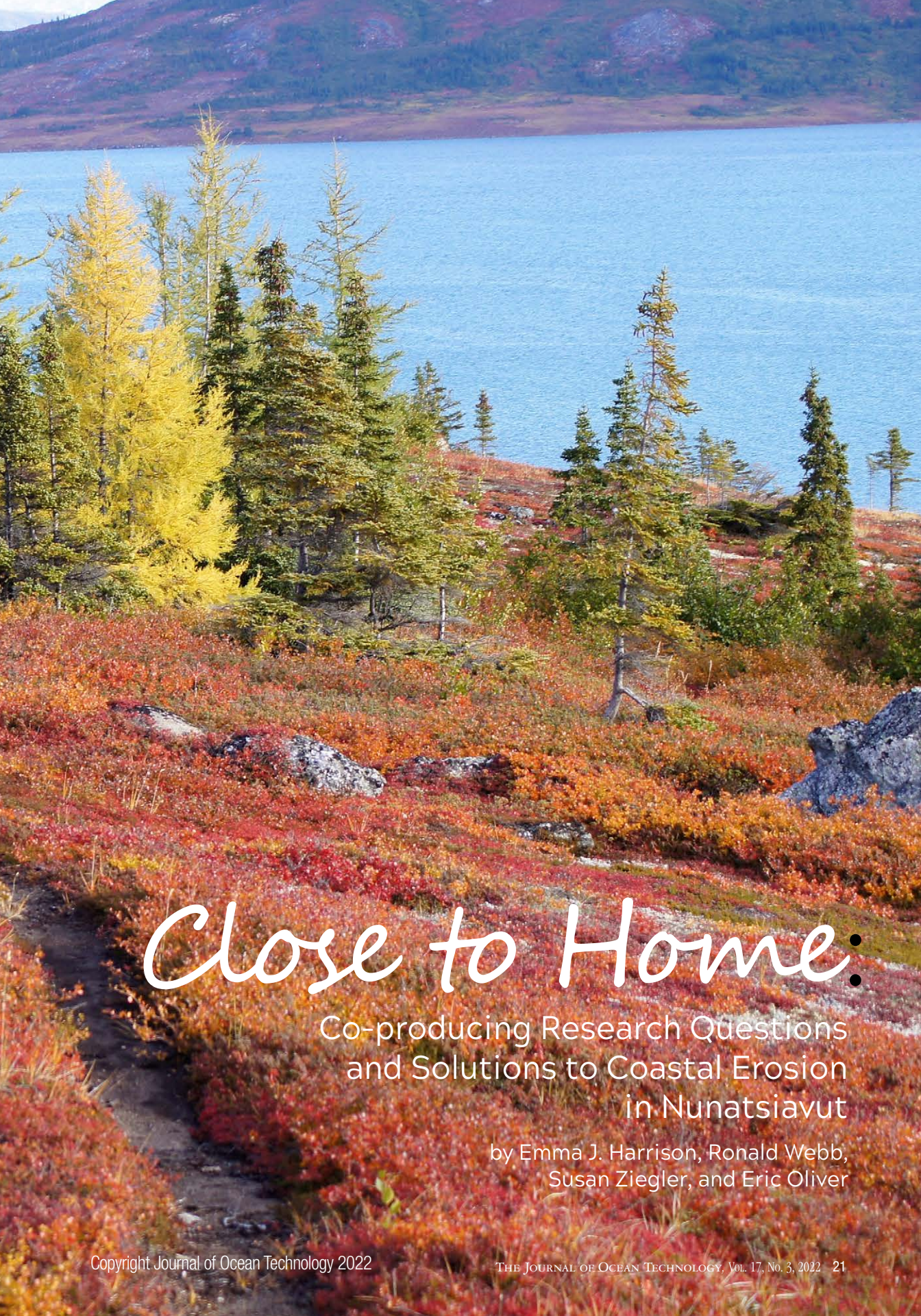

Close to Home:

Co-producing Research Questions and Solutions to Coastal Erosion in Nunatsiavut

by Emma J. Harrison, Ronald Webb, Susan Ziegler, and Eric Oliver

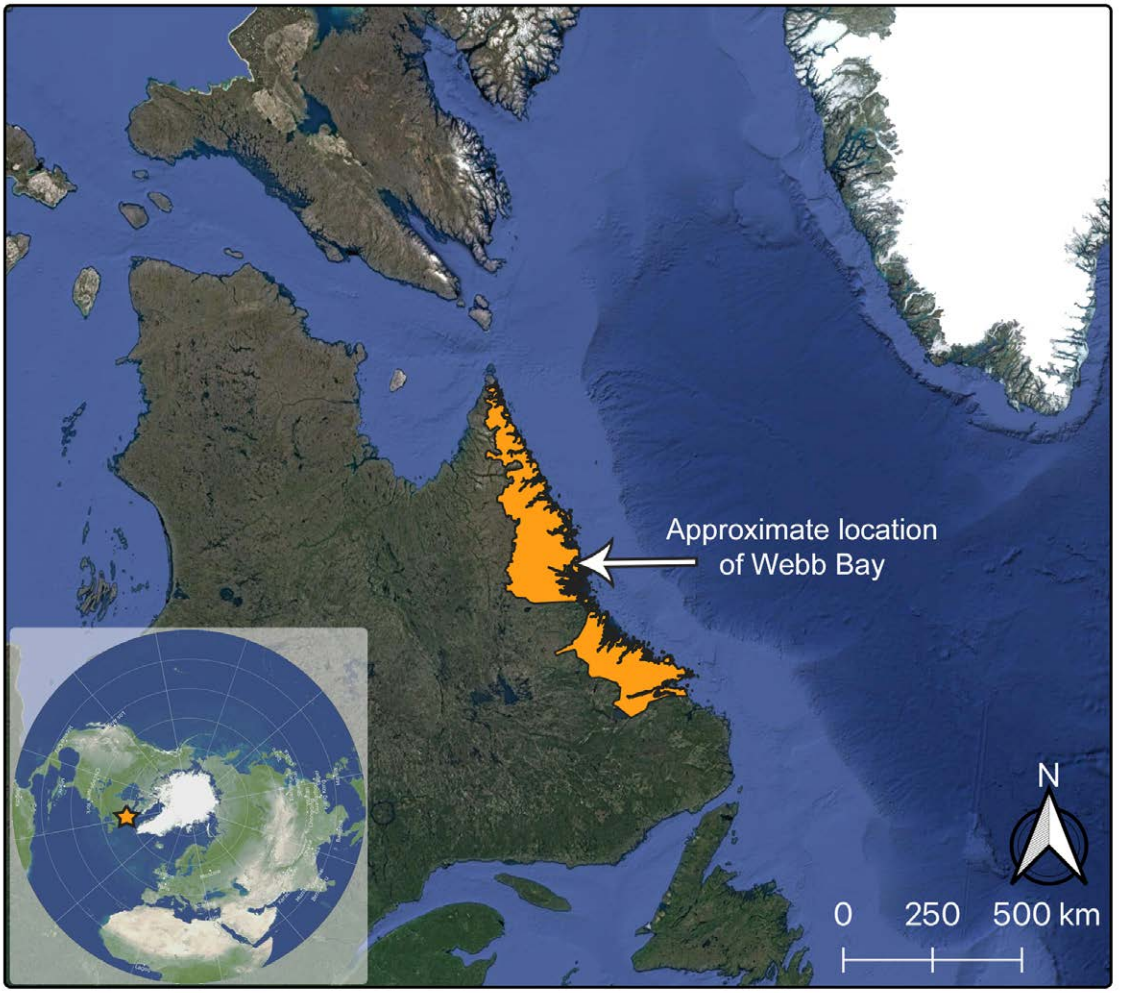

Figure 1: Nunatsiavut Land Claim area identified in orange with an arrow pointing to the approximate location of Webb Bay. Inset map showing a global polar view with a star marking the location of Nunatsiavut.

Introduction

Climate change impacts have long been considered a "wicked problem." Their causes are multiple and complex, characterized by intertwined environmental and social processes. Their solutions are sometimes intractable and often carry their own distinct harms. Situated within this precarity is an urgency to act. How can we proceed in ways that are effective and responsible? Governments, institutions, and individuals are deeply motivated towards answering this question. And yet, climate change research and funding for adaptation are part of an emerging economy that overwhelmingly benefits people from nations implicated in the climate crisis.

This contradiction represents a dynamical similarity between climate change research and colonization, called out by Inuit Tapiriit Kanatami (ITK), the national representational organization for Inuit in Canada, in the *National Inuit Strategy on Research* (2018). "Inuit in Canada are among the most studied Indigenous peoples on Earth. The primary beneficiaries of Inuit Nunangat research continue to be the researchers themselves."

Although traditional perspectives on science advocate for depersonalizing and decontextualizing research to generalize findings, climate change problematizes this paradigm in many ways, especially through

the urgency to make research applicable to community resilience. The *National Inuit Strategy on Research* frames a directive to institutionally based researchers working in the North: regional research on the effects of climate change should be accountable to how it aids local communities in adaptive planning for the future. From a practical standpoint, this points to the need for ways in which researchers connect meaningfully with communities living on the frontlines of global change.

Here, we highlight the foundational role of Inuit knowledge, Inuit participation, and the structures of Inuit sovereignty in an ongoing research project to elucidate the linkages between climate change and accelerated rates of coastal erosion in Nunatsiavut. Nunatsiavut is an Inuit self-government region in northern Labrador and an Inuttut name meaning "our beautiful land" (Figure 1). While there is no formula for decolonizing research or co-developing projects with communities, we believe this project contains meaningful examples of a collaborative and reciprocal research praxis that can succeed because of the structures that Nunatsiavut, with its sovereignty, has created to facilitate people and place centred research.

Co-developing Research Approaches for Resilience to Climate Change on the Coast

When the first cabin went up in Webb Bay, they cut the tree trunks using a six-metre-long saw. One person would stand on scaffolding two storeys in the air holding onto one of the ends, while another person stood on the ground to work the other end. That cabin is still in excellent shape more than 140 years later, maintained by members of the Webb family. Members of the family gradually moved south to Nain where the children attended a residential school in the mid-1960s. Returning to the Bay, then and now, is a homecoming and represents continued connection to culture and the land. This year, the Webb brothers were again sawing and transporting trees to their homesites on the Bay. They laid the logs out along the beach and pounded rebar deep into the shore platform to hold them in place. Despite the better tools, it is still back-breaking work. This time, they are trying to save the homes in which they grew up.

Around five years ago, the bluff separating their cabins from the sea began to erode dramatically. According to local observations, the bluff would sometimes erode by centimetres when they were young. Now, it seems to give way by metres every storm (Figure 2). At this rate, they estimate that the first cabin will erode into the sea in a year or two. For the Webb family, who are multigenerational observers of this landscape and the natural processes that shape it, it is clear that something significant has changed in the ocean-atmosphere dynamics to make the coastline vulnerable.

This project is a research collaboration between institutionally based scientists, members of the Webb family, and Inuit researchers with the Nunatsiavut Government that aims to identify what environmental shifts are causing the rapid increase in coastal erosion. Both our objectives and our approach were co-developed. At the core of our research is a conceptual model explaining how the environmental systems in Webb Bay interact with each other, and what has changed over time. That model is derived from the intergenerational understanding and lived experience of Inuit. It includes how the dominant wind direction shifts over the seasons, which channels bring in major currents, the rivers that are important sediment sources, and the effects of sea ice formation and break-up on the land. This knowledge of how the landscape functions underpins our data collection campaign. Because this project is a collaboration between Inuit knowledge holders and scientists, we combine data and model frameworks generated from multiple ways of knowing to bear on our research questions.

Across the Arctic, coastal erosion is being accelerated by climate change. The mechanisms driving these changes are made complex by the interactions among

A view of the beach and bluff with pallets and logs positioned to absorb wave impacts and reduce erosion near the Webb family's homes on Webb Bay.

Family cabin constructed on Webb Bay ~140 years ago (left). Mike and Joe installing logs to protect the eroding shoreline (right). All pictures credited to Susan Webb.

Figure 2: Scenes of erosion in Webb Bay.

meteorological, oceanographic, and terrestrial systems emerging at the nearshore environment of the coast. The causal drivers of heightened erosion may be unique features of high-latitude environments. Sea surface and air temperature has raised erosion rates in the Beaufort Sea by melting permafrost in ice-rich coastal bluffs; and increases in erosion rates correlated with the declining extent of sea ice. Less extensive coastal sea ice created longer tracks of open water and lengthened the fetch, or distance over which the wind blows, building larger wind swell waves with greater power to erode the coast. However, nearly all high-latitude coastal erosion studies focus within the Arctic Circle, which is subject to different weather patterns than the north coast of Labrador, which is entirely south of 60°N. These studies also tend to work with satellite-derived data products at large spatial scales while the coast of Labrador is highly variable on small scales, consisting of a complex of fiords, headlands, large bays, and offshore islands and islets. In the proposed collaborative research, we

Figure 3: Google Earth view of Webb Bay and the surrounding land and water. Inset map showing a zoomed in view of the homesites on a Canadian topographic map.

take a targeted monitoring approach in Webb Bay over the course of a year and make comparisons with historic and modelled data in order to assess the beach and bluff stability under current, historic, and potential future geomorphic conditions.

Dynamics of Geomorphic Change in Webb Bay

Webb Bay is located ~30 km north of Nain, the largest and most northern of the five Nunatsiavut communities. The Nunatsiavut coastline is complex and rocky. It is deeply incised by fiords and shielded by hundreds of small, nearshore islands. Weather and ocean conditions can be highly variable over short distances. Webb Bay is a relatively large feature, ~16 km long and nearly 8 km across at its widest point. Two large channels connect the eastern end of the Bay with the Labrador Sea, one oriented north and the other to the south. Directly east, the Bay is blocked from offshore currents by Aulatsivik Island.

The homesite sits on a bluff above a curved, sandy beach that is inundated at high tide. A small river drains the interior periglacial lakes and bogs and forms a delta adjacent to the bluff. The coastline in the Bay is primarily rocky; the persistence of a pocket beach here likely depends on sediment supply from the river and its stabilization by the headlands of an interior embayment, which can be seen on the map in Figure 3. Beaches often form in the headlands of bays because the curvature of the shoreline offers protection from wave action.

Research has demonstrated that globally bay beaches evolve into a stable shape, conditioned to the normal wind and wave environment. Changes in the dominant swell cause a period of erosional adjustment

while the planform curvature of the beach rotates to meet the new angle or intensity of arriving waves. One hypothesis is that a new erosive regime initiated in Webb Bay in response to changes in the wind direction and the accompanying swell. Similarly, longer duration wind events or an increase in the effective fetch length could increase the wave height and cause geomorphic adjustment of the coastline. In either case, the erosion rate would slow as the form of the beach equilibrated to the new swell state.

Alternatively, storm impacts could be driving the inflated erosion rate either through increasing storminess or via linkages modulated by the changing sea ice regime. Historically, sea ice formed in Webb Bay in early November. It fastened to the shoreline and protected the coast from the severe storms that hit northern Labrador in the wintertime. That ice is forming later now due to climate change, leaving the shore vulnerable to storm surges and large tidal swells that undercut the bluff. This mechanism would have very different implications for the probable evolution of the coastline and for the effectiveness of erosion mitigation approaches. Storms can change the coast completely within a matter of hours, limiting the usefulness of model predictions based on average conditions. However, storm-driven erosion is correlated with wave run-up, which does have the potential to be estimated through spatial analysis and climate projections.

Webb Bay is a hot spot for coastal erosion in Nunatsiavut and it is important to understand whether this site is uniquely vulnerable or a bellwether of future conditions in the region. Cabins and cultural sites are disproportionately located along the coast, and often on sections of unconsolidated sediments such as beaches and bluffs. To make a link between this case study and the regional vulnerability to coastal change, we need to parse the key drivers of the accelerated erosion rate and apply this information to predictions of future change.

Project Goals and Methods

We endeavoured to design a methodology that would achieve multiple, related outcomes that blur the lines between "basic" and "applied" science. We define our goals as:

1. Demonstrate a research praxis that empowers and respects Inuit knowledge and challenges traditional perspectives on scientific data.
2. Contribute to the growing body of knowledge on how climate change is mechanistically linked to accelerated coastal erosion in high latitude regions.
3. Link site-specific data to vulnerability at a regional scale.
4. Identify realistic and functional adaptation or mitigation approaches to deal with the specific problem of erosion in Webb Bay.
5. Develop community-based monitoring procedures and horizontal partnerships that have tangible benefits for Labrador Inuit.

We will simultaneously monitor sediment transport on the coast and littoral, or nearshore, processes in a year-long monitoring study initiating in September 2022. Data generated will be used to quantify storm surge elevation, wave height, associated wind-field intensity and orientation, and the event-scale magnitude of erosion. Event-driven erosion rates will be tracked through repeat surveys with a hand-held laser scanning device and a field of erosion pins installed along the cliff line. Moored pressure gauges in the Bay will be used to construct a record of tides, waves, and storm surges. The contribution of storm surge to sea height will be determined by deconstructing sea level measurements into constituent parts: long-term trends, tidal elevations, and the storm surge residual. We can ground truth our measurements using an established gauge site at Nain Harbour which has ~50 years of sea level data. Comparison of the 2022-2023 records between Nain Harbour and Webb Bay will be used to establish a statistical relationship between the gauge sites, allowing us to put recent Webb Bay conditions in the context of the last 50

years. We will match the resulting record of storm surge height to wind data provided through collaboration with the Nunatsiavut Government's Archaeological Division and Oceans North, which operates a weather station in Webb Bay.

As a basis for comparison with the data generated in the yearlong monitoring study, our research will estimate historic baselines for key environmental parameters based on modelled data and observations made by the Webb family. Historic wind statistics will be computed from ERA5 which provides hourly estimates of atmospheric variables from 1950-present at high spatial resolution. Records of ice formation and irregular weather events were kept in logbooks by Joe and Ronald Webb, informing a time series of ice formation and break-up. To understand the geomorphic evolution of the coastline in relationship to offshore processes, we will model a range of wave obliquities that would have allowed the beach deposit to remain stable, given the coastal topography and bathymetry of the site. We endeavour to place boundaries on rates of coastal change averaged over long timescales, inferred with cosmogenic radionuclide dating to quantify the paleo-retreat rate of the coastal bluff and the sedimentation rate observed from nearshore submarine sediment cores. These quantities represent the magnitude of difference between present day erosion and the average erosion rate over much longer timescales.

Working with community members to identify the key dynamics at play in the local environment is a paradigm shift with powerful potential for enhanced adaptive capacity. Many northern communities are adapting to coastal change on their own with limited access to resources. Large-scale data generalizing landscape processes are less useful for predicting future changes than the detailed, place-based knowledge held by local experts. Such information is indispensable for scientific models that can support adaptive decision-making. For example, static bay beach concept is a theory from the field of coastal engineering that can be used to predict a stable beach form given information about wave direction and bathymetry. If the shifted erosion regime in Webb Bay is attributable to nearshore sediment transport processes, the predicted stable planform geometry of the beach can be modelled to estimate the magnitude and time frame of erosional adjustment. Model parameterization, and a reality-check of the model predictions, can be informed by local knowledge. The resulting information can feed directly into adaptive planning and decision-making. This and other theories can be used to model erosion mitigation measures prior to implementing them, a crucial planning step as coastal engineering often exacerbates the very problems it seeks to alleviate.

How Nunatsiavut is Moving the Needle Toward Community Relevant Research

We conclude by emphasizing that the collaboration underpinning this research cannot be ascribed solely to the individuals involved. Rather, the sovereignty structures present in Nunatsiavut make it possible to centre people and place in the research design. To do scientific work within Nunatsiavut, researchers submit an application to the Nunatsiavut Government Research Advisory Committee for review. This committee determines the project's value to Nunatsiavut, ensures that it does not replicate previous work, and determines what permits will be required. It also asks for communication strategies and training or employment opportunities that connect community members to the research. There are dozens of ways in which the Nunatsiavut Government (NG) research staff can help to improve research outcomes. In our experience, this has included making connections with researchers doing relevant work, providing accommodation in the research centre, advising on practical issues related to the region, and supporting field work.

It is hard to imagine a research project in Nunatsiavut being successful without the help of community members and the NG

research staff. Each community has a distinct geography, ecosystem, environmental concerns, and social context. There are quirks to the availability of food, transportation, accommodation, and research support. However, the role of the ITK and NG researchers is not to ensure "successful" research outcomes as defined by investigators and funding agencies from outside the region. It is about course-correcting from the serious historic harms of colonial research.

Western academics and institutions have a long and problematic history of extractive research on Indigenous lands. ITK clearly defined this problem and its far-reaching consequences in the *National Inuit Strategy on Research*: "The relationship between Inuit and the research community is replete with examples of exploitation and racism. Research has largely functioned as a tool of colonialism, with the earliest scientific forays into Inuit Nunangat serving as precursors for the expansion of Canadian sovereignty and the dehumanization of Inuit. Early approaches to the conduct of research in Inuit Nunangat cast Inuit as either objects of study or bystanders. This legacy has had lasting impact on Inuit, and it continues to be reflected in current approaches to research governance, funding, policies, and practices." This statement reflects a perspective shared by many Indigenous communities globally.

In her 2015 memoir, *The Right to Be Cold*, Sheila Watt-Cloutier writes: "The future of Inuit is the future of the rest of the world – our home is a barometer for what is happening to our entire planet." Beyond their positionality on the frontlines of global environmental change, Inuit have positioned themselves as leaders in decolonizing research. That groundwork has produced examples of the fruitful ways in which combining knowledge approaches can bridge the gaps limiting our ability to address rapid environmental change. Even as the sovereignty of many Indigenous peoples remains unrecognized by colonial or settler governments, researchers and their affiliate institutions can shift their research modalities to affirm the autonomy and dignity of displaced, marginalized, or colonized communities. Prior decades of climate change research have made one thing very clear: new modalities are needed if we are sincere about addressing the "wicked" problems posed by climate change.

Dr. Emma Harrison is a postdoctoral fellow in the Department of Oceanography at Dalhousie University. She obtained a PhD in earth sciences from Scripps Institution of Oceanography at the University of California, San Diego, and held a previous postdoctoral appointment in geological sciences at Stanford University. Dr. Harrison is interested in decolonizing methodologies and research justice as science praxis. Her current work supports community-engaged monitoring of changes in the coastal marine environment of Nunatsiavut, in northern Labrador, as a member of a research collaboration between the Ocean Frontier Institute and the Nunatsiavut Government called Knowledge Co-Production and Transdisciplinary Approaches for Sustainable Nunatsiavut Futures. She co-founded the Center for Interdisciplinary Environmental Justice (@Decolonize4Climate), an organization that works for decolonial environmental justice and non-extractive climate change solutions. Her previous research in the field of geomorphology focused on the development of new geochemical applications to trace sediment transformation and transport in soils, hillslopes, rivers, and coasts.

Ronald Webb is an Inuk member of the Nunatsiavut community based in Nain, Nunatsiavut. Mr. Webb is well respected for maintaining traditional Inuit knowledge and values, as well as for his long history of contributions to research and community development. He currently serves on the board of the Torngat Secretariat, the organization that manages and implements the Torngat Wildlife and Plants Co-Management Boards. He was a co-owner of Sikumuit Environmental Monitors, Ltd., an Inuit business that does environmental monitoring in relation to numerous large-scale development projects in Nunatsiavut and surrounding regions. Within this organization, Mr. Webb has monitored the Voisey's Bay ship track, conducted ice and wildlife monitoring/surveying through combined Inuit and scientific approaches, conducted bear monitoring and shipping advising on the Saglek Remediation Project, conducted baseline

environmental surveys for the Voisey's Bay Nickle Mine, and led a socio-economic monitoring program in Nain, among other activities. Prior to the Labrador Inuit Land Claims Agreement, he performed many of these duties as a member of the Labrador Inuit Association, the predecessor of the Nunatsiavut Government. He has experience as a trucker and commercial fisherman, and is a lifelong hunter and trapper. Webb Bay is his familial and ancestral home.

Dr. Susan Ziegler is a professor of earth sciences at Memorial University in Newfoundland and a Canada Research Chair in boreal biogeochemistry. She obtained a PhD in marine science from the University of Texas at Austin in 1998 followed by a postdoctoral fellowship at the Carnegie Institution of Washington and an assistant professorship at the University of Arkansas in biological sciences. Her research involves the use of biomarkers and stable isotopes to track elements as they cycle through aquatic and terrestrial ecosystems, in order to understand how ecosystems function and respond to environmental change. She enjoys working within those ecosystems closer to home enabling observations over time. This has led to her establishing the Newfoundland and Labrador Boreal Ecosystem Latitudinal Transect with colleagues as a research platform for investigating carbon cycling, climate change effects, ecosystem functioning, and water quality across a mesic boreal forest climate transect. Her current role as a project lead in a research collaboration between the Ocean Frontier Institute and the Nunatsiavut Government called Knowledge Co-Production and Transdisciplinary Approaches for Sustainable Nunatsiavut Futures now provides her opportunity to learn more about ecosystem understanding from those having longer and deeper experiences with the environment in the region.

Dr. Eric Oliver is an assistant professor of physical oceanography in the Department of Oceanography, Dalhousie University, Halifax, Nova Scotia, Canada. His research interests involve ocean and climate variability across a range of time and space scales including extreme events, the predictability of climate variations, the influence of modes of variability on the ocean, and the role of climate change on the mean state, variability, and extremes of the climate system. He is of Inuit descent with roots in Nunatsiavut (northern Labrador) and is interested in Indigenous perspectives on climate, weather, and the ocean, and understanding both Indigenous and scientific knowledge of these systems.