Welcome to the Winter 2020 NORTH EDITION issue of **THE ZONE**, the CZCA newsletter

CZC2020 Iqaluit Conference Update

Organized by the Coastal Zone Canada Association and the Marine Environmental Observation, Prediction, and Response Network (MEOPAR)

We are excited to report many high-quality abstracts were accepted for the Coastal Zone Canada conference in Iqaluit, June 14th to 17th, 2020. The Steering Committee is busy arranging the content into an exciting and interactive agenda for the conference.

Some important updates:

- Registration is now open! We have used the generous sponsorships of our partners to keep the costs as low as possible. Regular $400. Youth $300. Students $200.

- The draft agenda and a list of accepted abstracts for special sessions, oral presentations, and posters is available on our website. Explore the content to learn more about this opportunity to observe the changing Arctic and plan for our future together.

- Travel support will be available for youth and students from the North. Check our website for updates and details on how to apply for assistance.

- It is not too late to sponsor the conference and join MEOPAR, the Birds of Nunavut team, the Nunavut Wildlife Management Board, and WWF – Canada in shaping the agenda and funding additional student/youth participation from the North.

In this issue

THE ZONE

Inuit Qaujimajatuqangit: Planning and Preparing for the Future

SAVE THE DATE: June 14-17, 2020

CZCA's biennial conference series will be held in Iqaluit, Nunavut at the Frobisher Inn from June 14 to 17, 2020.

Never been to northern Canada? Here is your opportunity for a once-in-a-life-time chance to combine professional development and exploration of Nunavut!

CZC 2020

Iqaluit 2020: Themes and Accepted Abstracts

Updated Sub-Themes Based on Abstract Submissions:

Climate Change - Threats, Risks, Impacts, Resilience and Adaptation Opportunities

Coastal Science and Engineering in a Changing Climate

The Arctic Blue Economy

Arctic Shipping

Innovation, Technology, Monitoring and Research

Advancements in Coastal and Marine Planning, Conservation and Management (includes MPAs and MSP)

Building Coastal and Ocean Literacy with Youth

Impacts on, and Mitigation and Sustainable Development of Coastal and Marine Ecosystems

Integrating Indigenous and Inuit Knowledge to Advance Integrated Coastal and Oceans Management

Marine Plastics, Contaminants, Pollution and Waste

Renewable Energy Needs and Opportunities in the Coastal Zone

Adaptive Co-management in the Arctic

Youth-to-Youth / North-to-South Sharing, Learning and Developing Plans Together for the Future

Federal Commitments to the Arctic Peoples, Communities, Culture, Economy, Infrastructure, Well-being and Ecosystems

Approved Abstract - Unsorted (final agenda TBD):

The earth has tilted on its axis": Inuit Knowledge and Climate Change .

Adaptive co-management for an ice-free Arctic: decision-making incorporating Inuit and scientific knowledge to manage marine mammals in Nunavut.

Addressing the threat of underwater noise to marine life in Canada.

An evidence-based approach to coastal flood risk reduction.

Arctic Coast: A transferrable framework for community-led coastal research and monitoring.

Assessing underwater noise pollution in the Out Bay of Fundy.

Benthic marine debris in the Bay of Fundy, Eastern Canada: Spatial distribution and categorization using seafloor video footage.

Building ocean literacy for youth in Nunavut: development of curriculum materials for Nunavummiut.

Building the Iqaluit Coastal Environmental Baseline Program based on Community Expertise.

Capacity development to promote collaborative coastal resource management and community-based monitoring in the Arctic.

Challenges and possibilities of the application of Marine Spatial Planning in the Canadian Arctic.

Characterization of marine benthic biodiversity in the Canadian Arctic with emphasis on nematode communities.

Coastal and Ocean literacy initiatives – an environmental scan and engagement opportunity.

Coastal area's matters in the face of Economic Developments: Realities from Guyana.

Coastal Flood Mitigation Canada: Promoting Evidence-based Approaches to Coastal Flood Risk Reduction.

Collaborative survey development and training to understand Inuit uses and needs for weather, water, ice and climate information.

Community-Based Shipping Monitoring Activities in Cambridge Bay, Nunavut.

Conservation narratives around fisheries co-management in Nunavut: Exploring commonalities between Inuit knowledge and Western approaches.

Creating Ecosystem Accounts for Canada's Oceans.

Cross-weaving Inuit Knowledge with Scientific Knowledge for effective Wildlife Decision Making in Nunavut.

Determining quantity of microplastics in surface water and beach sediment of near-shore marine environments of Atlantic Canada.

Dumping and marine protected areas in Canada.

Eco-Anxiety: Working on the Edge.

Empowering community-based decision-making for coastal resources through a participatory Marine Spatial Planning approach.

Grant-writing capacity enhancement for southern- and northern-based Early Career Researchers.

Green Ribbon Champion: Recognizing Excellence in Coastal Beach Stewardship on Lake Huron.

Hidden beneath cold seas: The importance of winter observations in understanding the dynamics of shallow subtidal benthic habitats.

How can we apply biogeochemistry to achieve consistent management of watershed, coastal water and aquaculture? Challenges in an oligotrophic bay of Japan.

Implementation of the Polar Code in Canada and the United States: Status and Prognosis for the Next Phase, with Special Consideration of the Impact on Inuit Communities in Arctic Canada and Alaska.

Infusing local knowledge into low-impact shipping policy: An adaptation to increased shipping activity and climate change in Arctic Canada.

Institutions, Indigenous Peoples, and Climate Change Adaptation in The Canadian Arctic.

Inuit Marine Monitoring Program CZCA Update 2020.

Inuit oral knowledge: Its place in designing decision support systems for marine and coastal management.

Kelp forests are the dominant coastal habitat in the eastern Canadian Arctic.

Learning from experience to advance the operationalization of integrated coastal and marine management.

Management and Monitoring in Marine Protected Areas: Building a case for increasing Canada's conservation footprint.

Marine Planning on the North Pacific Coast – Results and Lessons from the Marine Plan Partnership (MaPP).

Measuring biological and functional composition of benthic communities: a potential tool for evaluating the relative value of intertidal habitats.

Minding the gap: Using community-based monitoring data in wildlife co-management decision making.

Mobilizing sea-ice Inuit Qaujimajatuqangit for travel safety.

New (2019) Marine Protection Standards for Canada's Oceans .

Putting community values on the map: linking Inuit community conservation priorities with a regional conservation strategy.

Putting community values on the map: linking Inuit community conservation priorities with a regional conservation strategy.

Risk of invasive coastal fouling organisms due to maritime shipping: an experimental in-transit mussel survival example.

Scrubbers: turning air pollution into marine pollution.

Ship Emissions in Canadian Northwest Atlantic and Arctic Waters: Is there a Need for Consistency and Equity?.

SmartICE demonstrates a work-integration social enterprise approach for training and employing Inuit youth in their communities.

SmartICE supports community-based fishery and tourism enterprises in increasingly unpredictable sea-ice conditions.

Strategic Planning of Coastal and Marine Resources of Bangladesh to Enhance Climate Changed Resilience.

The Coastal Environmental Baseline Program: Characterizing Coastal Ecosystems through Engagement with Local Communities and Stakeholders.

The Nunavut Marine Council: Utilizing the Shared Experience and Knowledge of Nunavut's Institutions of Public Government to Inform the Management of Marine Areas.

The Potential of Beach Tourism in Nova Scotia Based on a Coastal Scenery Evaluation System.

Tools for Fostering a Sustainable Living Shoreline Program.

Toward Enhanced Environmental Governance in the Gulf of St. Lawrence.

Tracking ecosystem change through collaborative coastal environmental baseline data collection: a case study in the Port of Saint John, New Brunswick, Canada.

Traditional areas and shipping routes around them.

Using WWF-Canada's Network of Priority Areas for Conservation (PACs) as the conservation foundation for future Marine Spatial Planning efforts in the Canadian Eastern Arctic.

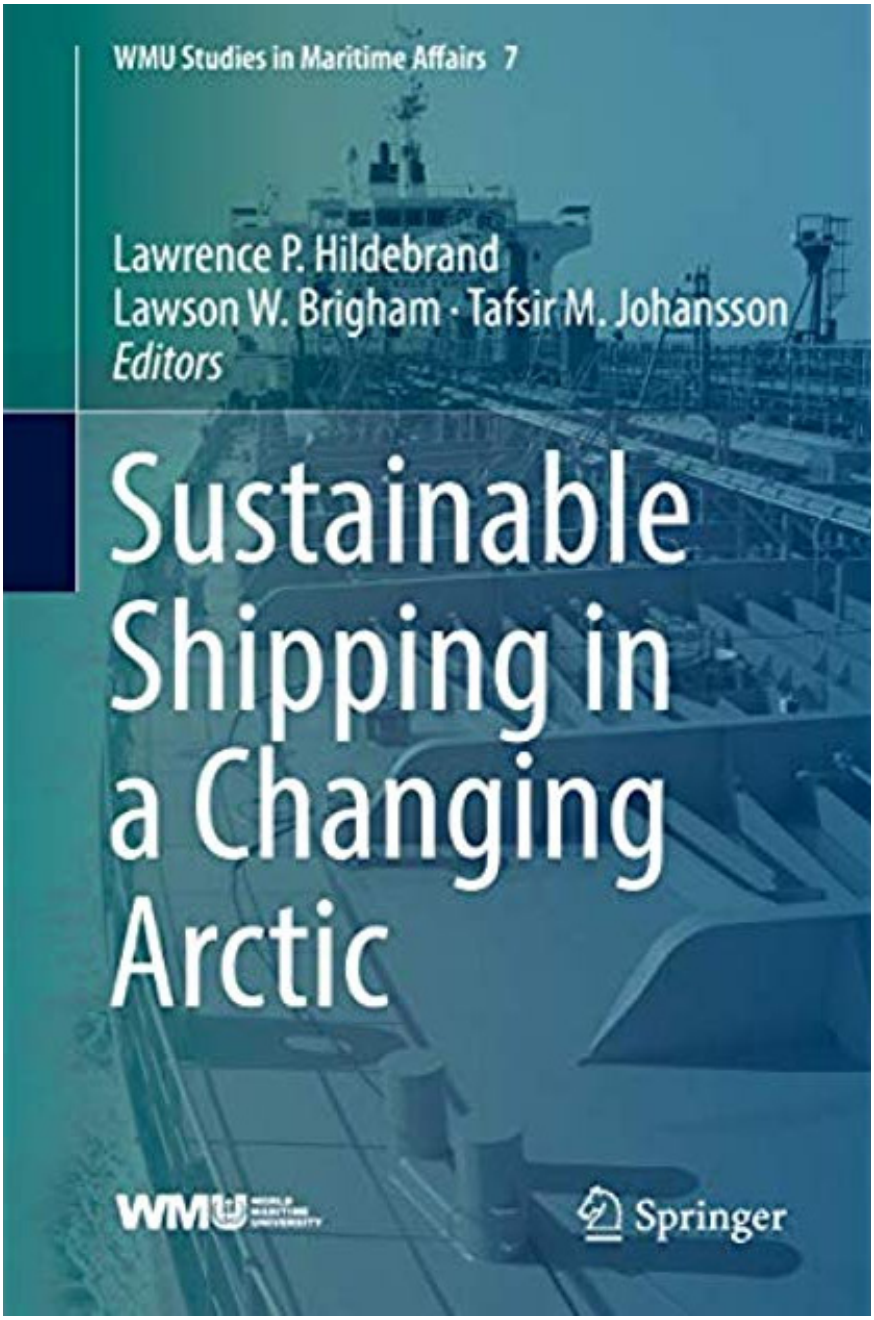
Which are the highest risk aquatic invasive species in the Canadian Arctic? A horizon scanning exercise.

Wildlife health surveillance - Tracking trends in a changing world.

Book Review: Sustainable Shipping in a Changing Arctic

Dr. Larry Hildebrand, World Maritime University
Victoria Fernandez Coastal and Water Resources Engineer, CBCL Ltd.

From almost the first day I arrived at the World Maritime University in Malmö, Sweden in April, 2013 as Professor and Canadian Chair in Marine Environmental Protection, I became engaged in lively discussions around the rapidly changing Arctic, and what this could mean in terms of risk and opportunity for the shipping sector. These discussions swirled among the faculty and students at WMU and our parent organization, the International Maritime Organization (IMO), a Specialized Agency of the United Nations. The topic was also of great interest and relevance to Transport Canada, the sponsor of the Canadian Chair at WMU.



Given this strong interest, I was tasked with organizing a major conference on the topic of Arctic shipping so that the relevant and responsible interests and stakeholders could convene to discuss and explore this topic from many perspectives and come away better prepared, individually and collectively, for the risks and opportunities that a changing Arctic will bring. The ShipArc (Safe and Sustainable Shipping in a Changing Arctic Environment) conference convened at WMU in August 2015. The conference included many excellent, timely and sometime provocative contributed and commissioned papers.

There was a strong consensus at the conference that these papers, along with some presentations and session summaries, should be compiled into a book to guide ongoing planning and preparing for shipping in a changing Arctic. Published by Springer in 2018 and available for purchase, Sustainable Shipping in a Changing Artic provides technical and multidisciplinary discussions on the main principles underlying navigation opportunities in the Artic: safe navigation in polar waters (with focus in the Polar Code), monitoring and tracking of ships in the artic, regulatory frameworks, environmental conservation, training and skill development, sustainable business development and considerations for the future.

World experts in navigation, shipping and the new maritime Artic have written the book chapters with a foreword by Cleopatra Doumbia-Henry, President of the World Maritime University The book offers a holistic reference guide for individuals, communities, industries, organizations and governments interested in the expanding marine uses of the Arctic and its changing environment.

Indigenous Languages - Indigenous Knowledge systems: Contribution to Sustainable Coastal Resource Management

Chris Milley, President, NEXUS Coastal Resource Management Ltd.
Maria 'Bugsy' Delesalle, Vice-President, NEXUS Coastal Resource Management Ltd.

2019 was the United Nations International Year of Indigenous Languages in recognition of the important relationship between language, development, peace and reconciliation and the treat to Indigenous Languages from the dominance of colonial languages.

Language is a fundamental aspect of Indigenous society; Indigenous language is the root of traditional knowledge and is the means by which knowledge is transmitted orally between generations. Local Indigenous languages includes knowledge and understanding of the regions in which the Indigenous peoples have long inhabited. In no region is this more obvious than in Northern Canada where the Indigenous languages Inuktitut, Inuinnaqtun, Inuvialuktun, Chipewyan/Dene, Cree, Gwich'in, Slavey, Tlicho, Innu-aimun, Han, Tanana, Tutchone, Tagish, Kaska and Tlingit are being eroded by the dominant "colonial" languages. These languages use individual words and unique expressions to explain and describe the natural and spiritual world in which they have evolved and been spoken for millennia. As a result, Indigenous languages hold much traditional knowledge;

knowledge that is useful, if not necessary, for the sustainable management of Northern Canada's environmental resources.

By promoting the protection of Indigenous languages, the United Nations is working to advance the implementation of the United Nations Declaration of the Rights of Indigenous Peoples (UNDRIP). This Declaration, which was accepted by the Government of Canada in May 2016, was drafted to protect the inherent right of Indigenous nations use and participation in the governance of the lands, waters, and resources within their traditional territories. UNDRIP recognizes the important relationship between people, place, and their traditional governance systems, including language. Traditional knowledge has become a common focus of research and study in Canada, such as the SSHRC-funded Fish-WIKS research program. Much of this research has been to collect, map and catalogue information from Indigenous knowledge holders. However, this approach assumes that traditional knowledge is a collection of facts held by Elders and does not recognize the importance of the systems through which knowledge is accumulated, verified, and transmitted within Indigenous societies.

Mapping data is not the same as understanding the knowledge system.

Traditional knowledge systems are dynamic and evolve by acquiring new information through experience of community members, sharing this information orally amongst peers, verifying this information through social processes, and orally transmitting this information as knowledge between generations. The use of indigenous language is, therefore, a fundamental aspect of any traditional knowledge system. For example, Inuit Qaujimajatuqangit (IQ) is often referred to as Inuit "Traditional Knowledge" by non-Inuit, however, the broader meaning of the Inuktitut expression is "the Inuit way of knowing". IQ encompasses more than the sum of facts accumulated across many generations, it includes the way Inuit have acquired knowledge, the way this knowledge has been passed on, and the way this knowledge has been used to make decisions within Inuit society. IQ is a dynamic system and new knowledge is continually being accumulated and used within Inuit society.

As the Canadian Arctic becomes more accessible due to climate change and the region's abundant resources become the focus for development, it is necessary to understand the local environment to ensure new developments do not undermine environmental sustainability. Attempts have been made to gain this understanding through traditional knowledge studies. However, studies that extract information for use in a non-traditional management system undermine the value of the knowledge transmitted through generations which includes diverse information on the interconnected natural relationships of physical and biological resources upon which Indigenous nations have depended for millennia. These knowledge systems are an integral part of the sustained management of the region's resources.

As the International Year of Indigenous Languages comes to a close, it may be an appropriate time to consider new approaches to incorporate Indigenous knowledge in resource development and environmental management activities across the North, and instead of extracting and translating knowledge from Indigenous communities efforts should be made to engage local knowledge holders and speakers of local Indigenous language directly in the decision-making process.

ArcticKelp: an exciting new largescale research project explores the current state and future opportunities for seaweed in the Arctic (www.ArcticKelp.ca)

Kathleen MacGregor[1, 2], Karen Filbee-Dexter[2, 3], Ladd Johnson[2], Chris McKindsey[1], Kimberly Howland[4], Philippe Archambault[2]

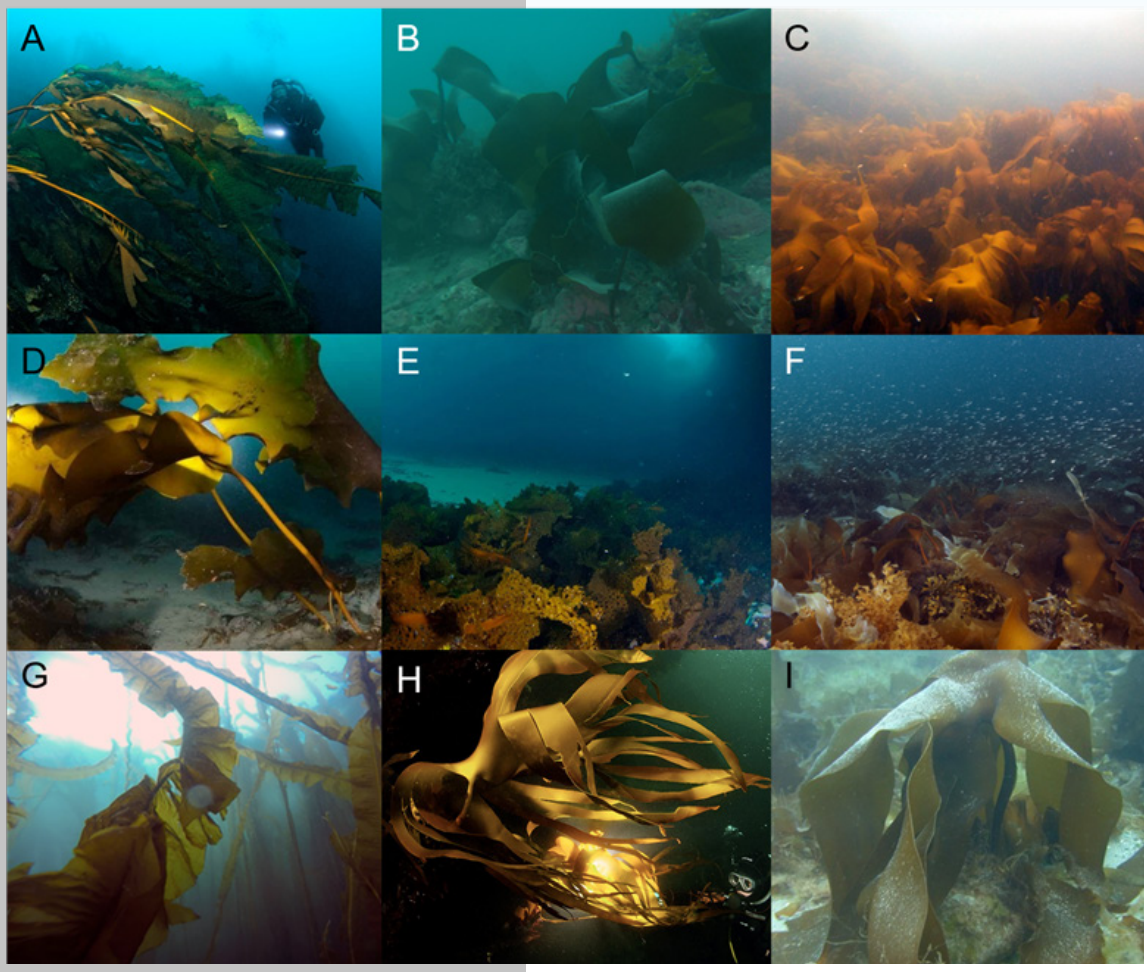
Shallow subtidal rocky reefs are areas of high productivity and diversity worldwide. In temperate waters, rocky reefs are often dominated by habitat-forming seaweeds such as kelp, which form dense assemblages. Such marine forests are not only a phenomenal source of primary productivity, but also create a three-dimensional structure that provides valuable habitat for a wide range of organisms, acting as both nursery grounds and critical foraging habitats for many harvested species. The potential distribution of kelp in the Canadian Arctic is astoundingly large (1000s of km of rocky coastline). Yet, there is little knowledge of the spatial distribution and character (e.g., dominant species, structure) of arctic kelp forests. Moreover, environmental conditions along these coastlines are changing rapidly, with sea ice retreat and warming temperatures predicted to expand the northern extent and overall productivity of kelp in the Arctic. ArcticKelp is a 3- to 5-year ArcticNet Research Project led by Prof. Philippe Archambault at Laval University that aims to answer three main questions about arctic kelp forests: 1) Where are they and what species are most abundant in which regions? 2) What is their value to northern communities? And 3) What effects will climate change have on their distribution and productivity?

Current State Of Affairs

The recipe for kelp forests in many regions of the world is deceptively simple: a rocky substrate, enough light to support growth, cool nutrient-rich waters, and low grazing pressure to ensure survival. Add to this mix protection from ice scour, and you have the formula for predicting the potential distribution of kelp in Arctic regions. As the first element of the formula, large stretches of coastline are likely rocky enough to support kelp forests, but there has been limited mapping of shallow subtidal bottoms of the Canadian Arctic. Concerning the second element, light to support growth, although sea ice and shortened day-length in winter reduce annual light in Arctic waters, light levels are probably high enough in many areas, particularly in waters less than 30 m deep, to support kelp growth. Regarding the third and four elements of the formula, sea urchins are one of the principal herbivores that graze on kelp; and although sea urchins are present in the Canadian Arctic, their relative abundance and population dynamics in this region are largely unknown. Finally, ice scour on exposed coastlines in shallow waters has an enormous impact on nearshore habitats and communities, including kelp forests. For this reason, areas that are ice-free for longer periods, or are otherwise protected from the impacts of sea ice, are of particular interest as possible sites of kelp forests.

A part of the ArticKelp project aims to carry out a large-scale survey of the presence and species composition of kelp forests across the eastern Canadian Arctic at sites that are likely to support kelp. To this end, teams of researchers and local collaborators have begun to collect information about subtidal kelp forests, targeting coastal areas between 5 and 15 m deep which should have high enough light levels to support macroalgae. These areas are Iqaluit NU and Churchill MB in 2011; Steensby Inlet NU and Deception Bay QC in 2012; the eastern coast of Baffin Island NU in 2014; Anaktalak Bay NL in 2018; Southampton Island NU in both 2018 and 2019; and in Eclipse Sound and Milne Inlet NU in 2017 and 2019. Using a combination of SCUBA diving and drop cameras, collaborative teams of researchers and local assistants have surveyed more than 46 sites. This effort represents an enormous leap forward in mapping the spatial extent of kelp forests in the Arctic and in documenting which species are found where. Further efforts are planned for the next four years. Surprisingly, kelp forests were found at almost all sites, and covered large areas of the seafloor. Overall, sugar kelp, Saccharina spp. (a group of kelp that are widely distributed in both temperate and polar latitudes), dominated in what appeared to be particularly productive areas such as sites in the northern portion of Labrador and around Southampton Island. Contrary to expectations, the endemic arctic kelp, Laminaria solidungula, was never the dominant species in the regions we surveyed. We are particularly interested in exploring what environmental factors are most important in determining the distribution and composition of the kelp communities we observed!

A key study area for this project is in the waters of Eclipse Sound near the community of Mittimatalik (Pond Inlet) where intensive exploration, including dive surveys, was carried out in 2019. Work elsewhere in the Arctic and previously published work in this area had led us to believe that kelp assemblages would be composed of a mix of species, dominated by Alaria esculenta in shallower waters and by Saccharina spp. and Laminaria solidungula at greater depths with a patchy distribution of Agarum clathratum in the deepest waters or in more marginal habitats where grazing rates are high or light more limiting. Instead we found an overwhelming dominance by A. clathratum at almost all sites and all depths. This may indicate that Eclipse Sound is a more marginal habitat for kelp than we had expected based on previous work. Future years will try to determine what factors are limiting the abundance and distribution of other kelp species by examining light, ice, grazing and kelp recruitment. These Agarum beds were, however, clearly functioning as important habitat for a large number of species with fish (cod and sculpins) and numerous invertebrate species (e.g., urchins, sea stars, brittle stars,



Photographs show examples of Arctic kelp forests: (A) Alaria esculenta in Greenland, (B) Laminaria solidungula in the Beaufort Sea, Alaska (Ken Dunton), (C) Laminaria hyperborea in Malangen fjord, Norway (Karen Filbee-Dexter), (D) Saccharina latissima on sediment in Russia, (E) Agarum clathratum and (F) mixed Saccharina latissima, S. longicruris, Alaria esculenta, Laminaria solidungula in Baffin Island, Canada (Frithjof Küpper), (G) Eularia fistulosa Aleutian Islands, Alaska (Pike Spector), (H) Laminaria hyperborea in Murmansk, Russia (Dalnie Zelentsy), (I) Laminaria digitata in Svalbard, Norway (Max Schwanitz). Provided by K. Filbee-Dexter. Figure previously published in: Filbee-Dexter K. (2019) Underwater Arctic forests are expanding with rapid warming.

shrimp and anemones) being strikingly abundant.

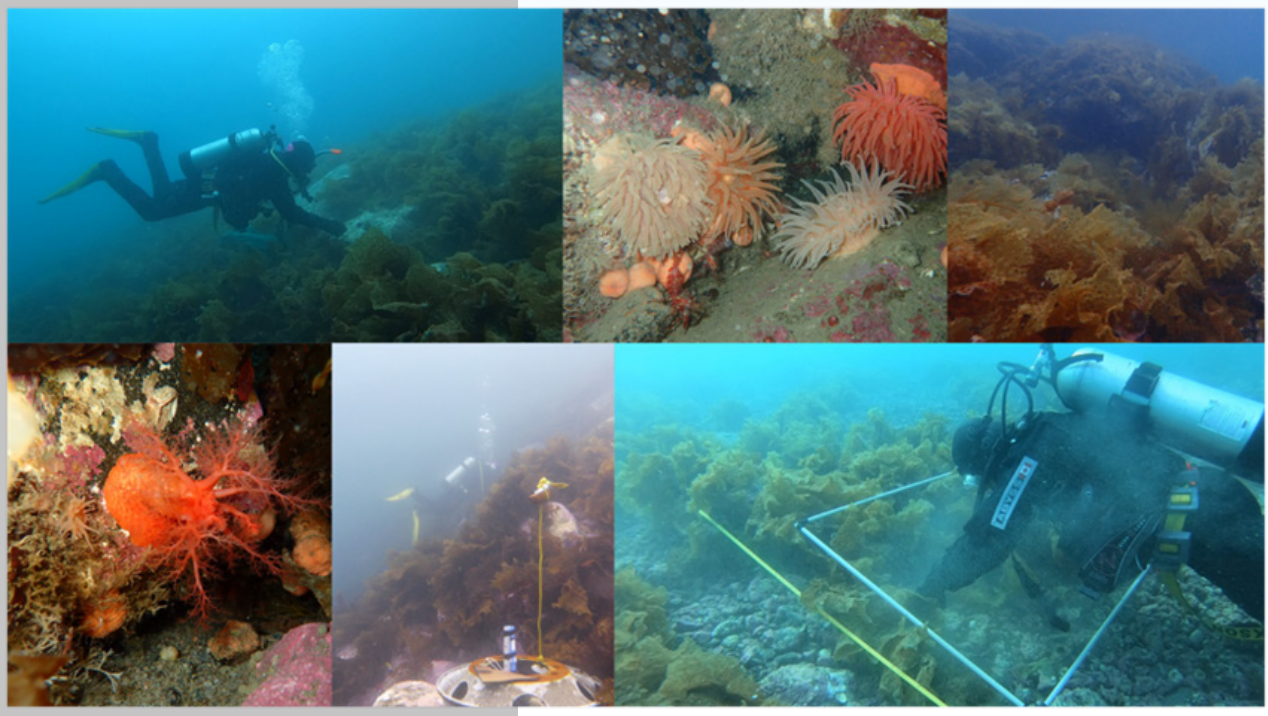
The Value Of Kelp Forests And Arctickelp For Northern Communities

An important objective of this multiyear project is to engage the local community in subtidal research and to facilitate exploration of, and familiarisation with, the local subtidal marine environment and its biodiversity. This year, the ArcticKelp team ran an informal interpretative touch tank filled with organisms collected during each day of diving work and carried out school visits at the end of our stay to share information about kelp forests and associated marine life with children at the elementary and high schools in Mittimatalik. We were also lucky enough to work with two invaluable local Inuit research technicians, Trevor Arreak and Cara Killiktee, who had previous training from the environmental monitoring program at the Nunavut College. ArcticKelp aims to include environmentally minded Inuit in our program both to provide an opportunity for input on project direction and development for ensuring that outcomes remain relevant for local residents, and to guide sample site selection so the time spent SCUBA diving is as efficient as possible.

A further goal of the project is also to provide opportunities for training and knowledge transfer, while also exploring possible economic opportunities that kelp forests could present for northern communities and local Inuit businesses. Kelp forests are clearly beneficial in that they provide habitat for fished or harvested species and their prey (for example, fish and shrimp). Some kelp species are also valuable as direct consumables. Indeed, the kuane (Alaria esculenta) we collected during sampling was consumed as a treat by the people in Mittimatalik). Some algal species are also being increasingly used as ingredients in traditional or traditionally inspired products (for example, Bowhead whale cosmetics with algal ingredients – UasaU Soap of Iqaluit). Future possibilities for economic development based on local kelp forests remain to be fully explored with communities but could include extraction of biomolecules as food additives, use of tannins such as those found in Agarum, or production of algal extracts for use in other products.

The Future Of Kelp In The Arctic

Climate change is having particularly dramatic effects in the Arctic, with reduced sea ice thickness and cover being the most marked and worrying trend. Although these changes clearly have negative effects on many species and coastal processes, including impacting the food security and access to traditional resources of the Inuit, future conditions may in fact benefit certain species. Indeed, kelp forests are predicted to expand their range as waters warm and annual light increases in coastal zones due to reduced ice cover. However, this prediction is potentially complicated by increased glacial melting and freshwater inputs in coastal areas; these inputs are often accompanied by increased turbidity and decreased light availability which may negatively impact kelp production. However, because so little is known about the distribution of arctic kelp species and the factors limiting their colonisation and



Photographs show SCUBA diving work in Eclipse Sound. From left to right: (top row) a diver sampling a dense Agarum clathratum forest; a group of large sea anemones (probably Urticina felinus); a mixed kelp community dominated by Agarum clathratum; (bottom row) a scarlet sea cucumber (Psolus fabricii); several scientific instruments deployed in a kelp forest; and a diver counting kelp and invertebrate species in a quadrat placed in a sparse Agarum clathratum forest. All photos by K. MacGregor and K. Filbee-Dexter.

productivity, predicting future changes is very difficult. Given the ecological and cultural importance as well as the economic potential of kelp forest habitats, the research being carried out by the ArcticKelp project will provide critical information for arctic decision makers, leaders and entrepreneurs.

Arctickelp In The Coming Years

The ArcticKelp project is currently planning future research, science training and outreach activities, including a second field season of diving and other work in Mittimatalik in the summer of 2020. In addition, discussions are underway about possible surveys in other regions. Plans for capacity building through the implementation of Inuit-led monitoring of marine subtidal environments are also under development (for example, monitoring of the year-round light environment under the ice at certain key sites). A collaborative project led through Fisheries and Oceans Canada is developing related subtidal habitat mapping in Frobisher Bay (NU). We are also quite interested in gathering accounts of seaweed found on beaches following storm events and are exploring the possibility of linking these on-the-land observations with drop-camera or diver observations of nearby underwater environments. Finally, ArcticKelp is dedicated to integrating our work with local concerns and interests. We are already very excited about what future seasons of collaboration and work will bring and are looking forward to revisiting the amazing kelp forests of the Arctic next year!

References and Resources

Check out our website and blog at www.ArcticKelp.ca for more information about this project!

Filbee-Dexter K. (2019) Underwater Arctic forests are expanding with rapid warming. The Conversation (May): https://theconversation.com/underwater-arctic-forests-are-expanding-with-rapid-warming-113016

For examples of algal products and innovations:

- *https://nunavutnews.com/nunavut-news/perserving-inuit-culture-by-producing-bowhead-oil-cosmetics/ - UalaU Soap is a cosmetics company in Iqaluit using algal ingredients in some of their traditionally inspired products*
- *http://canadiankelp.com – Canadian Kelp is a British Columbia company producing kelp for human consumption*
- *http://organicocean.ca/fr/entreprise - OrganicOcean is a company in Quebec producing algal extracts for agricultural applications*
- *https://seabiosis.com/ - Seabiosis is a pioneer company in Quebec in the transformation of seaweed into food products.*

Acknowledgments

The ArcticKelp project would be impossible without the collaboration and help of many people, both during the planning and execution of this work.

The collaboration and support of the following organizations has made ArcticKelp possible: the Nunavut Fisheries association; the Nunavik Marine Region Wildlife Board; the Mittimatalik Hunters and Trappers Organization; the

The team (from left to right: Cara Kilikee, Katie MacGregor, Trevor Arreak, Karen Filbee-Dexter); trying on dive gear with Ladd Johnson; touch tank gang with Karen Filbee-Dexter. Photos by L. Johnson and K. MacGregor.

Department of Wildlife and Environment, Nunavut Tunngavik Inc.; Oceans North; the Circumpolar Biodiversity Monitoring Program (CBMP); Natural Resources Canada; Fisheries and Oceans Canada, including the DFO Strategic Program for Ecosystem-Based Research and Advice and the DFO Aquatic Invasive Species Monitoring Program; the Institute of Marine Research, Norway; the Polar Continental Shelf Program; Sentinel North; Memorial University of Newfoundland; Université Laval; Québec Océan; Glencore (Raglan Mine); Vale (Voisey's Bay Mine); and Baffinland (Mary River Mine). For invaluable help in the field, we would like to thank the crew of the MV Cape Race (2014); the crew of the MV William Kennedy (2018 and 2019); the crew of the MV Nuliajuk (2017 and 2019); the collaborative SIMEP research team led by CJ Mundy; our assistants in Mittimatalik and Eclipse Sound, Trevor Arreak, Cara Killiktee, Andrew Arreak, Tapisa Kasarnak and Markusi Jaaka; Leo and Myna Maktar for use of an amazing boat and discussions about observations of seaweed; the Mittimatalik HTO and particularly Joseph Arreak and Andrew Arreak for invaluable help organizing diving field work; the ECCC field station for providing an amazing base for working in Eclipse Sound; and of course, ArcticNet for providing financial and Amundsen Science for logistical support (particularly Cindy Grant and Lisa Treau De Coeli) to make this work possible.

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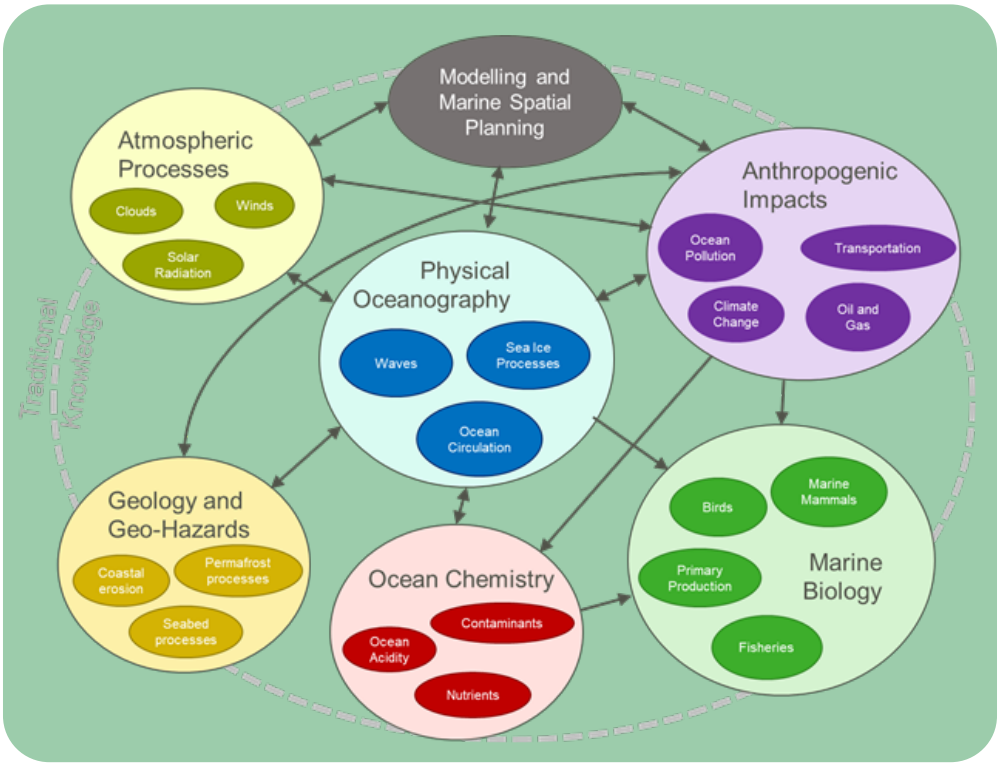
Variability of the Beaufort Ice-Ocean Environment: A Synthesis Report

Phil Osborne[1], Alexandre Forest[2] and Humfrey Melling[3]
Amundsen Science[2], Golder Associates[1] and Fisheries and Oceans Canada[3]

In the harsh and remote offshore Beaufort Sea, the acquisition of year-round information to guide decisions regarding potential resource development and conservation plans remains a challenge. In these remote and deepwater areas, direct human observations are very limited, if simply not existent. A practical approach is to deploy mooring-based instruments to quantify and characterize important processes, such as ice thickness and motion, ocean currents, temperature and salinity fields, and sediment fluxes. Such information is essential to the design, planning and assessment of infrastructure, of practices and of contingency measures necessary for safe and cost-effective offshore development, including for oil and gas exploration and maritime shipping. Instruments attached on long-term moorings also provide a wealth of information on the marine ecosystem that may be impacted by offshore development through an integration of physical oceanography data that can be used to interpret regional ecosystem stressors.

This paper is a high level summary of the development of a Synthesis Report of current physical oceanographic scientific information and an integrated analysis of the Beaufort Sea environment. The Synthesis Report project is a multi-year project being undertaken as a collaboration between Amundsen Science, Fisheries and Oceans Canada (DFO) and Golder Associates (Golder). The overall objective of the project is to link up-to-date scientific knowledge of the Beaufort Sea to issues important to environmental assessment and decision-making related to resource assessment and



development in the region. The project forms part of the Beaufort Strategic Regional Environmental Assessment (BSREA). The Synthesis Report will summarize the state of knowledge regarding the physical marine environment by incorporating analysis and review of existing data and new data obtained from mooring observatories in the southern Beaufort Sea and state-of-the-art modelling products. A primary focus of the report is the identification of seasonal and inter-annual trends and variability in the ice-ocean environment.

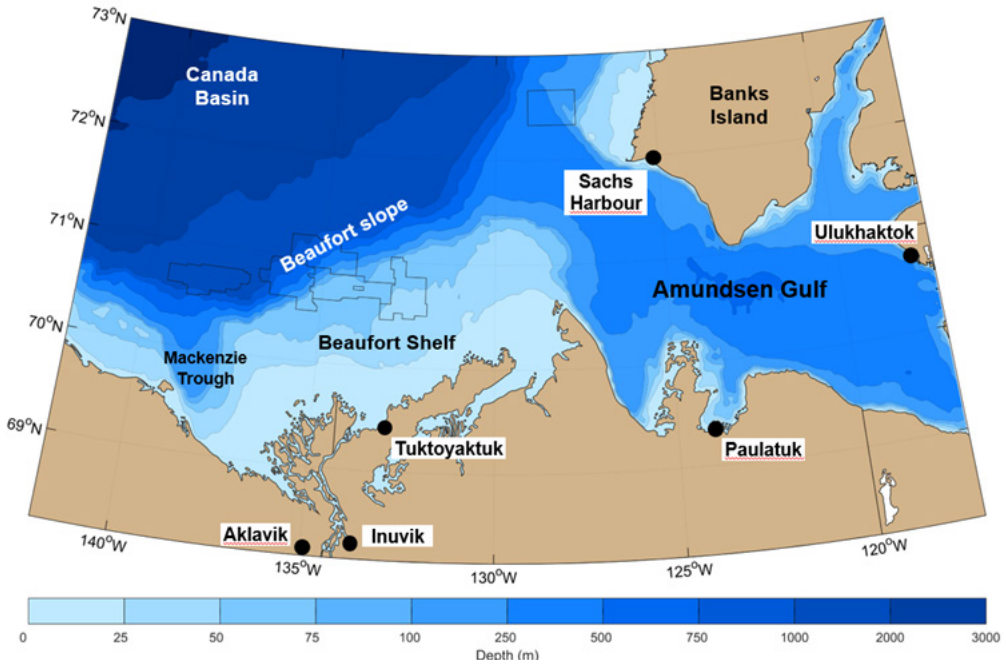


Figure 1: Map of the Canadian Beaufort Sea Region. Beaufort Sea oil and gas lease areas are outlined in black.

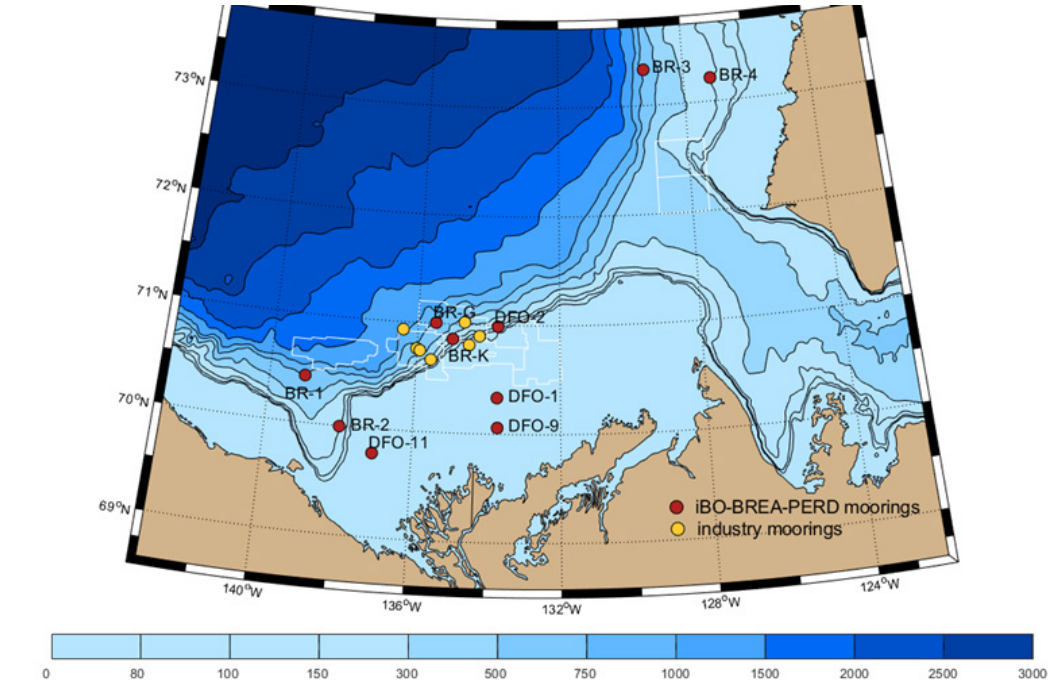


Figure 2: Bathymetric map of the Canadian Beaufort Sea showing the location of selected iBO moorings (in red) and industry moorings (in orange).

A key motivation is to improve computer models for ice and ocean current prediction that are a necessary aspect of safe and environmentally sustainable resource development projects and resources management. This involves using available and new ocean and ice data to contribute to the validation of modelling tools.

Setting

The Beaufort Sea is an outlying sea of the Arctic, also referred to as the Canada Basin. It covers approximately 476,000 km2 and reaches depths of 3500 m or more (Figure 1). This report is focused on the Canadian Beaufort Sea shelf (or Mackenzie shelf) and shelfbreak region, an environment of complex wind driven (Eckman), shear and density driven flows. These processes are the main subject of this report, as they are thought to be key mechanisms for driving mixing between the shelf and deeper Atlantic and Pacific waters in the Beaufort Gyre and for ice formation.

The shelf is relatively narrow (120 km wide) and runs northeast for 530 km. The average depth is 35 m (Carmack and MacDonald, 2002), but importantly it is dissected by a series of large channels, including the Mackenzie Trough, which facilitate subsurface mixing (Blasco et al., 2013). The shelfbreak occurs at 80 to 100 m depth and the slope angle increases from 2° to 6° into the deep Canada Basin. The Mackenzie River to the south is the largest Arctic river input into the Beaufort Sea in terms of sediment load (~127 × 106 t yr-1) and the fourth largest in terms of freshwater discharge (330 km3 yr-1), of which most occurs between May and September (MacDonald et al., 1998).

A decade of New Oceanographic Data

Since the 1980's oceanographic moorings have been deployed in the Canadian Beaufort Sea to collect oceanographic data. The data were collected to maintain long-term monitoring records. The collected data span the fields of oceanography (i.e. physical, chemical, biological, and geological), and include measurements ocean currents and waves, water temperature and salinity, ice thickness, coverage and dynamics, bottom and suspended sediments, and phytoplankton abundance

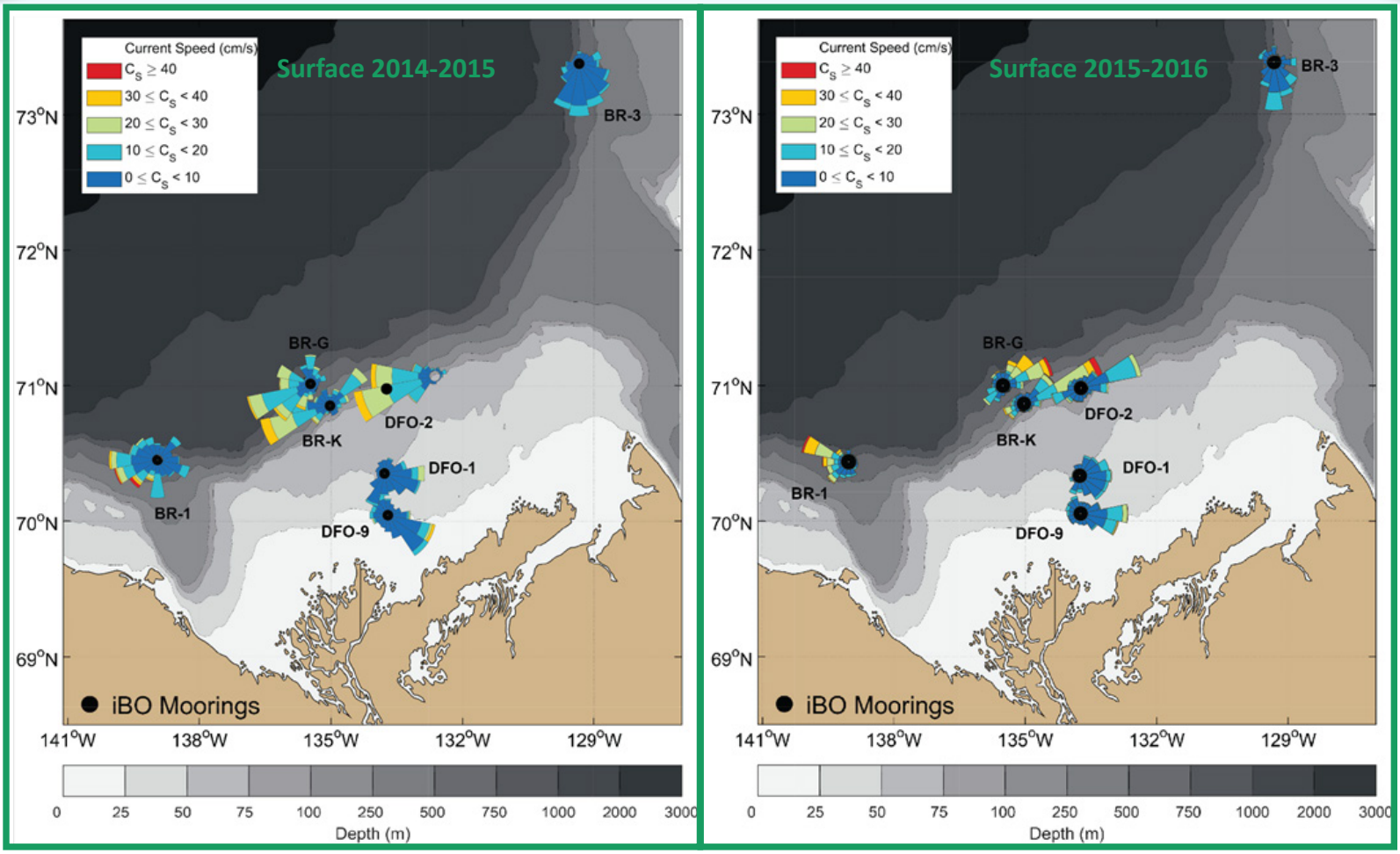


Figure 3 & 4: Near-surface currents for the open water season for low-pass filtered current velocity data from the bin depth nearest bin depth to 50 m at all moorings except DFO-1 and DFO-9 which are closest to a bin depth of 20 m. Data when sea ice was present (winter-spring) were filtered out. Roses indicate toward where the current is flowing.

The focus of the Synthesis Report is on the physical data collected between 2009 and 2017 at 17 moorings sites in the southern and eastern Canadian Beaufort Sea (Figure 2). High data recovery rates (>90%) reflect the success of the field program which resulted in high quality information across the mooring sites, including near-continuous datasets at several sites from 2009-2019.

Data Overview

The new and existing data are being integrated to characterize ice and ocean processes including the movement and mixing of ocean waters, seasonal variations of sea ice, frequency and severity of extreme conditions. In some instances datasets spanning nearly 3 decades have been combined. Herein we provide a high level summary of several key findings thus far.

Wind and Wave Climate

The Meteorological Service of Canada Beaufort (MSCB) hindcast data from 2009 to 2015 are used alongside wave measurements from the observation program to summarize the wind and wave climate and identify and characterize storm events. The data comparison shows that seasonal variation in wave height in the southern Beaufort Sea is closely coupled to the seasonal variation in ice cover and wind. The data show that the highest wave heights were typically measured in September and October. Analysis of waves reveals a strong trend to higher sea states for the worst wind storms each summer with mean swells increasing at a faster rate than mean seas, supporting the notion that the changes in wave height are driven more by the reduction in ice cover than changes in the wind climate. This trend is expected to persist as open water areas continue to increase with reduced sea ice cover, described below.

Sea Ice Climate

Sea ice climate is summarized using satellite imagery and observations from up-looking sonar (IPS) on the moorings. Over the long-term, Arctic sea ice extent is known to be decreasing and the remaining ice cover is younger and thinner. Satellite imagery over the southern Beaufort Sea from 2009 to 2018 suggests a trend towards earlier breakup of ice at a majority of the mooring sites and more variability with regards to the date of ice formation. Up-looking sonar (IPS) incorporated in the moorings provides continuous information on the presence of pack ice, its movement, draft (viz. the submerged part of its thickness), topographic variation and extreme features.

Ocean Circulation and Water Masses

An overview of the ocean circulation processes in the southern Beaufort Sea,

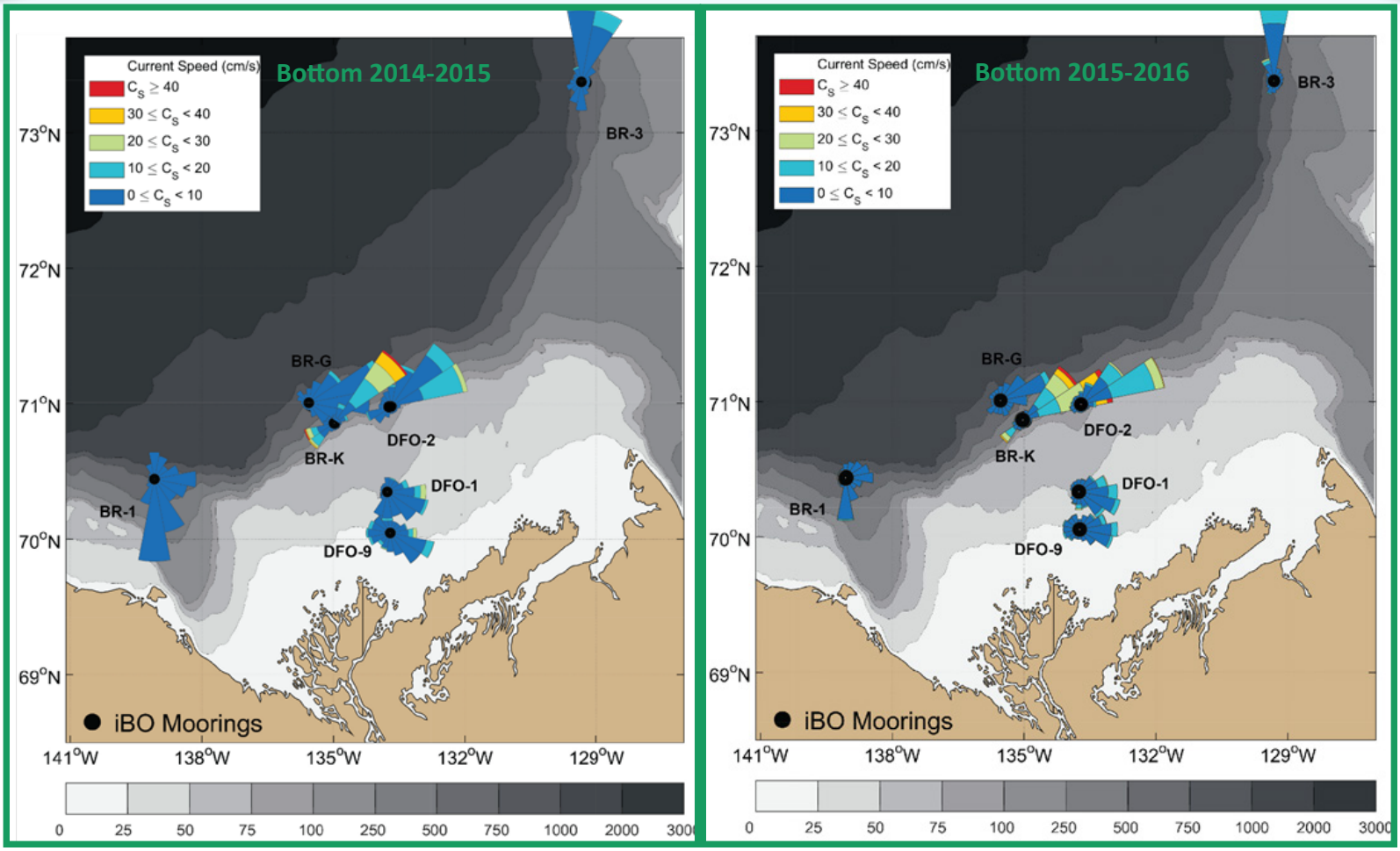


Figure 5 & 6: Near-bottom currents for the open water season for low-pass filtered current velocity data from the bin depth nearest to bottom at each location. Data when sea ice was present (winter-spring) were filtered out. Roses indicate toward where the current is flowing.

including an assessment of the vertical and temporal structure of ocean currents and water masses is provided. The general circulation in the Beaufort Sea is closely related to the dominant anti-cyclonic current system of the Arctic Ocean. A moderate high-pressure system centered over the Beaufort Sea drives the Beaufort Gyre which forms a clockwise circulatory system, bounded by the Beaufort shelfbreak jet to the southeast. On the inner to mid-shelf, ice drift, ocean circulation, and the trajectory of the Mackenzie River plume, are highly variable and linked to wind dynamics. ADCP measurements from the moorings are used to characterize currents across the shelf, shelfbreak, and slope (e.g. asillustrated in Figures 4 and 5) and provide evidence and insight into large-scale circulation patterns (coastal current on the shelf, shelf-break jet, and Beaufort Gyre current on the lower slope) and small-scale patterns (eddies and upwelling and downwelling events).

Model and Data Comparisons

Comparisons are under way between the observation data and the Government of Canada's Regional Ice-Ocean Prediction System (RIOPS) model. RIOPS is a high-resolution operational ocean forecast model with 3-hourly data available for download from January 1, 2017 onward. The project team is reviewing and assembling several case studies of ocean circulation, in particular, the characteristics, variability, and features of the shelfbreak jet and offshelf currents for comparison with RIOPS to evaluate model performance and gain insight to synoptic behavior of the ice-ocean system.

Anticipated Project Benefits

The Synthesis Report is expected to provide several benefits to the BRSEA and communities, including the production of a baseline for monitoring change in the ice-ocean environment due to climate change or human activities; increased confidence in prediction of the ice-ocean environment; basis for the development of informed policies and guidelines that will take into account the physical environment as whole; and information for educational resources about the ice and offshore environment that may be used in northern schools and colleges. Traditional Knowledge information may be also available through liaison and coordination with Inuvialuit organizations to support soliciting Inuvialuit feedback on aspects of the Synthesis Report and streamline ongoing research activities. This will ensure that collected data are reported and made available in the most appropriate format for Inuvialuit organizations and can be used in support of decision making.

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News Items

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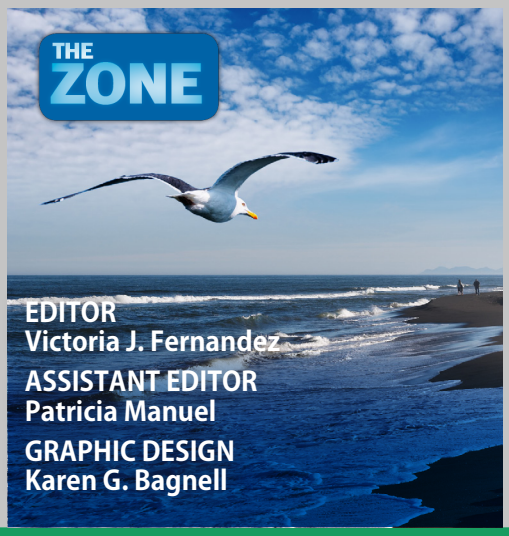
We would like to sincerely thank all of the contributors to this edition of the Zone, the authors of the papers and articles herein, as well as the reviewers.



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