Report: Assessment on Ocean Science in Canada

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Report: Assessment on Ocean Science in Canada

Executive Summary

The Networks of Centres of Excellence (NCE) MEOPAR was initiated in 2012 and is scheduled to conclude by March 31, 2023. Over the ten-year duration of the MEOPAR NCE, the landscape of ocean science, both in Canada and globally, has changed substantially. The environment in which MEOPAR currently operates is not the same as when it was launched almost a decade ago.

This assessment document examines the landscape of ocean science[1] initiatives that were in place when MEOPAR was launched, followed by a selected set of science initiatives – spanning across marine environmental observation, prediction, and response - both domestic and international, that were either in place in 2012 or have come on-stream in the interim period. It provides a backdrop to the discussions, now being initiated within the ocean science community, around what role MEOPAR should seek to take on as it moves from the NCE program to a new future.

Under the auspices of Canada's Oceans Act, Canada's Oceans Strategy was released in 2002, which defines the vision, principles, and policy objectives for the management of Canada's estuarine, coastal, and marine ecosystems. This was followed by Canada's Ocean Action Plan in 2004 which articulates a government-wide approach to seize opportunities for sustainable development.

The academic community, specifically the Canadian Consortium of Ocean Research Universities, was seeking opportunities (circa 2010) for collaboration in ocean research in Canada. They recognized the need for an assessment of ocean science in Canada and approached the Council of Canadian Academies. Two reports were prepared, which for the first time in Canada, identified the priority areas of ocean science and a set of associated actions.

Around the same time, the Galway Statement was signed by the European Union, Canada and the USA in May 2013. The goal of the joint Statement was to better understand the Atlantic Ocean and promote the sustainable management of its resources. The Government of Canada announced funding in 2014 for new measures that would achieve a world-class tanker safety system to strengthen marine safety measures to protect the public and the environment.

By looking at the ocean science landscape today we find a number of further undertakings that help to maintain the momentum such as: the Ocean Research in Canada Alliance; the UN Sustainable Development Goals; the Commonwealth Blue Charter; the Belém Statement on

[1] *While this Assessment Paper refers to "ocean science" throughout the text, it should be considered in the broadest sense to include both ocean and coastal regions as well as a range of marine environmental sciences.*

Atlantic Ocean Research and Innovation Cooperation; the Government of Canada's Oceans Protection Plan; and the UN Decade of Ocean Science for Sustainable Development (2021-2030).

We also see a series of very active Canadian ocean science networks and initiatives that are monitoring, collecting and managing huge amounts of data, developing innovative tools and undertaking science and technology development activities in the ocean and along the coasts of Canada. Several examples of these networks and initiatives are briefly described in this report. There are many additional examples that could also have been included; however, those included within the report provide an overall cross-section.

Clearly, there has been a significant investment and progress in ocean science, ocean protection and sustainable ocean use initiatives over recent years. Some outstanding questions include:

- Are all the activities coordinated as well as they could be?
- Are there gaps in our overall approach to ocean science, protection and use?
- What else should we be doing?
- How do we sustain these efforts?

Acknowledgement: The material contained within this Report has been primarily drawn from website documentation for each component. These websites are referenced under each section for further information and reading.

1. Introduction and Background

The Networks of Centres of Excellence (NCE) MEOPAR was started in 2012 and will conclude by March 31, 2023. Over the ten-year duration of the NCE, the landscape of ocean science, both in Canada and globally, has changed substantially. The environment in which MEOPAR currently operates is not the same as when it was launched almost a decade ago.

This assessment document describes the landscape of ocean science initiatives that were in place around the time that MEOPAR was launched. It then goes on to discuss selected ocean science initiatives, both domestic and international, that were either in place in 2012 or have come on-stream while MEOPAR has been active.

Examining the ocean science landscape in a collective view will enable the identification of both strengths of various ocean science initiatives as well as potential gaps that could present opportunities for a renewed MEOPAR. This information will help set the context of ocean science in Canada at this time and will form the backdrop for the proposed development of the next iteration of MEOPAR.

2. Context of Ocean Science – circa 2012

Canada's Ocean Strategy:

Canada's Oceans Strategy is the Government of Canada's policy statement for the management of estuarine coastal and marine ecosystems released in 2002. National in scope, *Canada's Oceans Strategy* sets out the policy direction for ocean management in Canada. While the *Oceans Act* provides a framework for modern ocean management, the associated *Canada's Oceans Strategy* provides for an integrated approach to ocean management, coordination of policies and programs across governments, and an ecosystem approach. The *Strategy* defines the vision, principles and policy objectives for the future management of Canada's estuarine, coastal and marine ecosystems and more specifically supports policy and programs aimed at: Understanding and Protecting the Marine Environment; Supporting Sustainable Economic Opportunities; and providing International Leadership.

Canada's Oceans Strategy in general, and ocean governance in particular, is much more than a federal government responsibility. It is a collective responsibility shared by all. Accordingly, ocean governance under the *Strategy* has core commitments to work collaboratively within the federal government, and among levels of government; share responsibility for achieving common objectives; and engage Canadians in ocean-related decisions in which they have a stake.

Under the *Strategy*, ocean governance will advance in three specific areas. First, the federal government will develop, support and promote activities to establish institutional governance mechanisms to enhance coordinated, collaborative ocean management across the federal government and with other levels of government. Second, the *Strategy* seeks to implement a

program of Integrated Management planning to engage partners in the planning and managing of ocean activities. As the cornerstone of the governance approach, Integrated Management establishes decision-making structures that consider both the conservation and protection of ecosystems, while at the same time providing opportunities for creating wealth in ocean-related economies and communities. Finally, the *Strategy* responds to the desire of Canadians to become engaged in ocean management activities by promoting stewardship and public awareness. Ocean stewardship means acting responsibly to conserve the ocean and its resources for present and future generations.

Building on both the *Oceans Act* and the *Oceans Strategy*, the Canadian government developed an *Oceans Action Plan* in 2004. The Government is committed "to move forward on its *Oceans Action Plan* by maximizing the use and development of ocean technology, establishing a network of marine protected areas, implementing integrated management plans, and enhancing the enforcement of rules governing the ocean and fisheries, including rules governing straddling stocks." Furthermore, the *Action Plan* articulates a government-wide approach to seize opportunities for sustainable development. The following four inter-connected pillars support the *Action Plan*:

- International Leadership, Sovereignty and Security;
- Integrated Oceans Management for Sustainable Development;
- Health of the Oceans; and
- Ocean Science and Technology.

Finally, the *Oceans Action Plan* serves as the overarching umbrella for coordinating and implementing ocean activities and provides a framework to sustainably develop and manage Canada's ocean spaces.

For more information: https://www.dfo-mpo.gc.ca/oceans/publications/cos-soc/index-eng.html
https://www.dfo-mpo.gc.ca/oceans/publications/oap-pao/index-eng.html

Canadian Consortium of Ocean Research Universities

The Canadian Consortium of Ocean Research Universities (CCORU) was launched circa 2010, seeking opportunities for collaboration in ocean research in Canada.

CCORU recognized the need for an assessment of ocean science in Canada and approached the Council of Canadian Academies to conduct two studies which were precedent setting. For the first time in Canada, the priority areas of ocean science were identified and a set of actions were identified. The Council of Canadian Academies reports have proven to be very effective in guiding the investment of ocean science in Canada in this time period. One area that may best exemplify this guidance in investment is in the development of the Canadian Integrated Ocean Observing System (CIOOS). CIOOS has seen funding from both the government and the academic sectors come together to address the priority of developing an integrated system for ocean observations in Canada (see more details below).

For more information: https://www.ic.gc.ca/eic/site/063.nsf/eng/h_97482.html

Council of Canadian Academies Reports: 2012**:** 40 Priority Research Questions for Ocean Science in Canada, and 2013: Ocean Science in Canada: Meeting the Challenge, Seizing the Opportunity.

The Council of Canadian Academies (the Council) is an independent, not-for-profit organization that supports independent, science-based, expert assessments to inform public policy development in Canada. The Council's work encompasses a broad definition of "science", incorporating the natural, social, and health sciences as well as engineering and the humanities.

In response to CCORU's request (see above) the Council undertook this work in two phases. First, they asked a Core Group of ocean experts from Canada and abroad to develop a set of priority research questions, which were published as 40 Priority Research Questions for Ocean Science in Canada. Second, the Council convened a Panel of Canadian and international ocean science experts to address the following charge, using the 40 research questions as a guide.

> "What are Canada's needs and capacities with regard to the major research questions in ocean science that would enable it to address Canadian ocean issues and issues relating to Canada's coasts and enhance its leading role as an international partner in ocean science?"

The Panel recognized that ocean science is becoming increasingly complex, multidisciplinary, multi-scale, and internationally connected. They concluded that addressing the 40 research questions will require new forms of alignment and collaboration both nationally and internationally. The Panel found that the seascape of ocean science in Canada is already changing in response to these needs. Innovative networks, such as the Networks of Centres of Excellence, are facilitating collaboration between scientists from universities, government, the private sector, civil society organizations, and communities. Novel funding opportunities, such as those offered by the Canada Foundation for Innovation, are enabling the establishment and management of large-scale infrastructure, such as vessels and observation networks, outside of federal government organizations. Consortia of actors, such as CCORU, are emerging to create momentum for change. These new networks and alignments have already resulted in several innovative, world-leading initiatives. Despite these advances, the Panel identified the following gaps in the coordination and alignment of the ocean science community in Canada, which are currently not being addressed:

- **The vision gap**: In contrast to other countries, or other disciplines in Canada, no comprehensive national strategy or vision currently exists for ocean science in Canada. This makes it difficult to prioritize needs and comprehensively plan investments for ocean science.
- **The coordination gap**: Addressing the increasingly complex issues of ocean science requires enhanced collaboration at the local, regional, national, and international levels,

and across disciplines and sectors. Despite the many instances of successful collaboration in Canada, coordination in key areas, such as ocean observation, is lacking, and support for research networks has often been constrained by temporary funding. More generally, there is no effective national-level mechanism to coordinate the allocation of resources and facilitate the sharing of infrastructure and knowledge among ocean scientists. This also hinders the sharing of resources and knowledge at the international level.

- **The information gap**: Limitations in access to, and availability and comparability of, information made it difficult to assess several categories of ocean science capacity. While many actors in ocean science maintain inventories for internal use, no existing national mechanism or repository systematically collects and regularly updates information on key research activities, infrastructure, and other capacities in ocean science for the entire country. Nations, such as Germany and the United Kingdom, have these inventories that are used not only to assess capacity, but also to inform development of national science strategies and plans on a regular basis and to prioritize decision-making on research infrastructure investments.

The Panel concluded that addressing these gaps is essential if Canada is to meet the growing needs of ocean science with limited resources, and make best possible use of existing capacities to meet the challenges and seize the opportunities of ocean science. None of the current and emerging alignments, consortia, or networks can address these gaps singlehandedly. Doing so requires a national effort involving the entire community of ocean scientists in Canada, as well as users of ocean science including policymakers, entrepreneurs, communities, and civil society.

For more information: https://cca-reports.ca/reports/40-priority-research-questions-for-ocean-science-in-canada/

https://cca-reports.ca/reports/ocean-science-in-canada-meeting-the-challenge-seizing-the-opportunity/

Galway Statement on Atlantic Ocean Cooperation

The Galway Statement was signed by the European Union (EU), Canada and the USA in May 2013. The goal of the joint Statement was to better understand the Atlantic Ocean and promote the sustainable management of its resources. The Agreement aimed to connect the ocean observation efforts of the three partners. The work also studied the interplay of the Atlantic Ocean with the Arctic Ocean, particularly in relation to climate change.

The Galway Statement led to the creation of the Atlantic Ocean Research Alliance (AORA) that was launched 2013. Priority areas of cooperation identified by the three members included aquaculture; ocean literacy; ocean observation; knowledge sharing; marine biotechnology; seabed and benthic habitat mapping; shared access to research marine infrastructures; and ecosystem approach to ocean health and stressors.

While Canada participated in AORA research groups and projects, Canadian scientists were not eligible for direct EU funding. The North Atlantic initiative did provide opportunities for Canada to align domestic ocean science priorities. Selected research groups and projects in support of the Galway Statement included participation from MEOPAR funded researchers, as the priorities aligned closely with those of MEOPAR. The Galway Statement supported several projects of relevance to MEOPAR activities. The project - AtlantOS (an All-Atlantic Ocean Observing System) – saw the greatest involvement from MEOPAR researchers.

For more information: https://www.atlanticresource.org/aora

Galway Statement -
https://ec.europa.eu/research/iscp/pdf/galway_statement_atlantic_ocean_cooperation.pdf

World Class Tanker Safety – Government of Canada Funding

In May 2014, the Government of Canada announced funding for new measures to achieve a world-class tanker safety system in Canada. The objective of these funded measures was to strengthen marine safety measures to protect the public and the environment. The Government departments in receipt of World Class Tanker Safety funding included Transport Canada, Environment and Climate Change Canada, Fisheries and Oceans Canada and the Canadian Coast Guard. Measures included the following two key areas:

> **Prevention Measures**: A key component of this measure related to modernizing Canada's navigation system. In 2014, mariners navigated Canada's waterways using primarily visual navigational markers (e.g. buoys, lighthouses, paper nautical charts, etc.) and the marine industry strongly encouraged a movement to e-navigation as it would result in better, more reliable navigational information, leading to increased vessel safety and more efficient operations.
> **Preparedness and Response Measures:** Within this measure, the Government of Canada funded efforts to develop and implement tailored response plans in four areas that have the highest level of tanker traffic:
>
> - the southern portion of British Columbia;
> - Saint John and the Bay of Fundy, New Brunswick;
> - Port Hawkesbury, Nova Scotia; and
> - Gulf of St. Lawrence, Quebec.
>
> Lessons learned from these four areas are to be used to refine area response planning models and enable implementation of similar spill-response planning approach in other locations across Canada.

The Government's priorities to strengthen oil spill prevention, preparedness and response is reflected in the priorities identified and activities implemented within MEOPAR. This work includes, amongst others, the research projects with British Columbia; work under the Observation, Prediction and Response Cores; and the new Tracer Release Experiment in the Gulf of St. Lawrence.

For more information: https://tc.canada.ca/en/world-class-tanker-safety-system-new-measures-strengthen-oil-spill-prevention-preparedness-response-polluter-pay-principle

3. Ocean Science Landscape Today

Ocean Research in Canada Alliance

The Ocean Research in Canada Alliance (ORCA) was established in 2016 to improve the coordination of ocean science and technology (S&T) in Canada. ORCA brings together Canada's ocean S&T community to increase collective knowledge, align efforts, and forge stronger collaborative ties. The ORCA Community of Practice is the forum to share information, discuss priority issues, connect with the wider science community, and collaborate on ocean S&T initiatives in Canada. Membership (with over 500 members and 160 organizations) reflects the diversity of Canada's ocean community, and includes academic institutions, government departments, granting agencies, non-governmental organizations, Indigenous groups, and industry.

ORCA has identified the following six challenge areas to which it has focused its efforts to date:

1. Align Efforts, Plans, and Funding Around Shared Priorities
2. Advance the Sharing of Infrastructure
3. Science in Support of Public Policy, Regulation, and Decision Making
4. Encourage Innovation and the Commercialization of Knowledge and Technology
5. Work Towards a Cohesive Voice for the Ocean Science Community in International Fora
6. Communicate Ocean Science and Technology

ORCA has held a number of meetings and workshops to advance its goal and to which MEOPAR has contributed. Work conducted by ORCA is represented, in large part, by the following three reports.

ORCA Building an Ocean Research in Canada Alliance Workshop, 2017 - Summary Report. In 2017, DFO convened leaders from the Canada's ocean science and technology community to discuss collectively how an ORCA could improve the overall coordination amongst the community through the identification of tangible forward looking initiatives.

ORCA Creating a Culture of Successful Collaboration Workshop, 2018 – Summary Report. The agenda focused on the six identified Challenge Areas (see above) with discussions on current activities and actions that the ocean science community might be able to take to address issues in each area.

ORCA Ocean Innovation and Technology Workshop, June 2019 – Summary Report. The agenda topics include:

- Introduction and background on ORCA;

- Discussion of ORCA Challenge Area 4 - Encourage Innovation and the Commercialization of Knowledge and Technology;
- Presentations of collaborative initiatives in the Canadian ocean technology sector;
- Participant engagement portion, where participants discussed several questions and provided potential solutions.

For more information: https://www.ic.gc.ca/eic/site/063.nsf/eng/h_97482.html

UN Sustainable Development Goals 2015 and 2030 Agenda for Sustainable Development

The UN Sustainable Development Goals, 17 in total, were adopted by all UN States in 2015, as part of the 2030 Agenda for Sustainable Development which set out a 15-year plan to achieve the Goals. Within Canada, the overall leadership is provided by Global Affairs Canada. This federal government department works closely with respective line departments, including Fisheries and Oceans Canada and Environment and Climate Change Canada.

There are several Sustainable Development Goals that relate to work conducted in marine environmental science in Canada, including: Goal 7: Affordable and Clean Energy; Goal 13: Climate Action; Goal 11: Sustainable Cities and Communities; as well as Goal 14: Life Below Water. These four goals in particular, amongst the total of seventeen goals, address aspects that relate specifically to the ocean and coastal regions of the globe. Goal 7 seeks to ensure access to affordable, reliable, sustainable and modern energy in which clean renewable ocean energy is expected to have a role. Goal 13 calls for urgent action to combat climate change and its impacts. The UN writes that climate change is affecting every country on every continent and that it is disrupting national economies and affecting lives. Weather patterns are changing, sea levels are rising, and weather events are becoming more extreme. Goal 11 relates to making cities inclusive, safe, resilient and sustainable. The world is becoming increasingly urbanized. Since 2007, more than half the world's population has been living in cities, and that share is projected to rise to 60 per cent by 2030. Many of the world's cities are located on coastlines making them vulnerable to changes in the nearby ocean, waterways and coastlines, including changes as a result of sea level rise, coastal erosion, increasing storm events, increasing urban temperatures extremes, etc. Finally, Goal 14 has as its objective to conserve and sustainably use the ocean, seas and marine resources**.** The description of Goal 14 notes that careful management of the ocean is a feature of a sustainable future but that at the current time, there is a continuous deterioration of coastal waters owing to pollution, and ocean acidification is having an adversarial effect on the functioning of ecosystems and biodiversity. The UN also states that saving our ocean must remain a priority. Marine biodiversity is critical to the health of people and our planet. Marine protected areas need to be effectively managed and well-resourced and regulations need to be put in place to reduce overfishing, marine pollution and ocean acidification.

In the global response to the attainment of these UN Sustainable Development goals, initiatives such as the Commonwealth Blue Charter and the UN Decade for Ocean Science for Sustainable Development have emerged. These latter two initiatives are described separately below as

they set the current context of global ocean science. The high-level initiatives have goals and objectives that are seen in MEOPAR's Strategic Plan and can translate into more specific actions.

An important step in moving forward on the UN Sustainable Development Goals was the 2018 Sustainable Blue Economy Conference. It was the first global conference on the sustainable blue economy and saw over 18,000 participants from around the world come together to learn how to build a blue economy that:

- Harnesses the potential of our ocean, seas, lakes and rivers to improve the lives of all, particularly people in developing states, women, youth and Indigenous peoples
- Leverages the latest innovations, scientific advances and best practices to build prosperity while conserving our waters for future generations

The conference was held in Nairobi, Kenya and was co-hosted by Canada, Kenya and Japan. Participating nations made commitments that would be implemented in support of a sustainable blue economy. Key amongst the 16 commitments made by Canada were: implementation of the $1.5 Billion Ocean Protection Plan (GoC); provision of $153 Million to build a knowledge-based economy (GoC and Ocean Supercluster); commitment to support capacity building for Kenya Coast Guard Service; promotion of the Commonwealth Blue Charter through work as a Knowledge Champion on Ocean Observations; and join the International Alliance to Combat Ocean Acidification.

For more information: https://www.un.org/sustainabledevelopment/sustainable-development-goals/
http://www.blueeconomyconference.go.ke/

Commonwealth Blue Charter

In 2018, the Commonwealth Blue Charter was signed by all 54 Commonwealth countries to actively co-operate to solve ocean-related problems and to meet commitments for sustainable ocean development. The Blue Charter helps Commonwealth countries work together on a fair, inclusive and sustainable approach to ocean protection and economic development. Within Canada, the lead is provided by Global Affairs Canada working closely with line departments such as Fisheries and Oceans Canada.

Action Groups have been formed to implement the Blue Charter, with ten topics identified, each with national champions. Canada has identified as the Commonwealth champion on Ocean Observation, with national funding support for this work. Other Action Groups of relevance to Canadians include those on Ocean Acidification; Marine Protected Areas; Ocean and Climate Change; Sustainable Blue Economy; and Sustainable Coastal Fisheries.

The pronouncement of Canada's championship in ocean observations reinforces the work that has been conducted by the MEOPAR Observation Core, and others within MEOPAR, to advance ocean observations in Canada.

The Commonwealth Action Group on Ocean Observations has identified the following areas for advancement, several of which align with MEOPAR's Strategic Plan:

- opportunities to increase the innovation, development and deployment of ocean observational technologies;
- accessibility of ocean observational data, knowledge and best practices among Commonwealth countries;
- political cooperation to better integrate ocean observational data, information and knowledge into decisions, products and services within the Commonwealth; and
- gender issues within the context of ocean science.

For more information: https://bluecharter.thecommonwealth.org/

Belém Statement on Atlantic Ocean Research and Innovation Cooperation

The Belém Statement was signed by the European Union, South Africa and Brazil in 2017. This follows on the Galway Statement for the North Atlantic cooperation, signed in 2013, and reflects a significant move towards a joint, integrated approach to research and development across the whole Atlantic Ocean and its bordering countries. Those countries, including Canada that signed the Galway Statement are included in the efforts under the Belem Statement. Within Canada, the lead is provided by Global Affairs Canada.

As the main instrument supporting the implementation of the Belém Statement, the All Atlantic Ocean Initiative (AANChOR) aims to bring together all relevant actors around the Atlantic to build the All Atlantic Ocean Research Community, and to identify concrete collaborative research and innovation activities across a range of key areas. Six areas have been identified:

- Climate Variability – including changes to the ocean's physical and biological processes
- Ocean Resources – ensuring responsible and sustainable fisheries management, aquaculture development, food security and biodiversity
- Ocean Observation – recognizing the need for sustained long-term observations via satellites, buoys, underwater vehicles, vessels
- Ocean Technology – needing new marine technologies and applications for data collection and monitoring, as well as to sustainably explore the ocean's resources
- Emerging Pollutants – better understanding the impact of emerging pollutants on healthy and sustainable ocean
- Polar Research – understanding this region's profound effect on the Earth's climate and ocean systems

The Belém Statement and the All Atlantic Ocean Research Alliance are supported by the European Union. While Canada may participate in research groups and projects supporting the All-Atlantic Ocean Initiative, Canadian scientists were not eligible for direct EU funding. The six key areas identified as research priorities provide direction for Atlantic Ocean research activities at the national level.

For more information: https://allatlanticocean.org/
Belém Statement: https://ec.europa.eu/research/iscp/pdf/belem_statement_2017_en.pdf

Oceans Protection Plan, Government of Canada Funding

In 2016, the Government of Canada launched the $1.5 billion national Oceans Protection Plan (OPP), the largest investment the Government of Canada has ever made to protect coasts and waterways. Funding was primarily provided to departments within the Government of Canada, including Transport Canada, Environment and Climate Change Canada, Fisheries and Oceans Canada and the Canadian Coast Guard. The OPP contained a large Grants and Contribution Program from which individual projects and initiatives outside of the Government could be funded for key partnering activities. An overview of the plan with its four major components is outlined below.

World-leading marine safety system: Canada's marine safety system ensures that authorities are ready and able to respond quickly to spills in Canadian waters. This includes the areas along three coastlines, the Great Lakes, the St. Lawrence Seaway and some inland waters. These OPP objectives include:

- Establishing 24/7 emergency response and incident management
- Increasing on-scene environmental response capacity, and improving oil spill response plans
- Acquiring new environmental response equipment for the Canadian Coast Guard
- Sharing near real-time information on marine traffic with Indigenous and coastal communities
- Modernizing Canada's marine safety regulation and enforcement regime

Preserving and restoring marine ecosystems: This component aims to preserve and restore marine ecosystems vulnerable to increased marine shipping and development. These OPP objectives include:

- preserving and restoring vulnerable marine ecosystems helping to protect marine mammals
- reducing the impact of day-to-day vessel traffic by learning from scientific research and local knowledge of Indigenous communities and other coastal residents
- increasing the number of fishery officers to support lead responders and enforce the law during incidents, and increasing our surveillance of protected areas

Creating stronger Indigenous partnerships and engaging coastal communities: Indigenous coastal communities share ties to Canada's ocean that span generations. They rely on them as a source of livelihood, food security, and valuable transportation routes. Under the OPP, Indigenous peoples and coastal communities across the country are engaged to:

- build new partnerships
- help groups participate in the marine safety system to work together on specific marine initiatives, and

- provide new boats, equipment and training that help local community members play an even more important role in marine safety

Stronger evidence base: Due to tanker traffic risks, research is conducted into how various types of oil and petroleum products behave when spilled in a marine environment. Using knowledge and scientific advice provided to oil spill responders, improvements will be made to response and decision-making. To provide the best scientific advice and tools for preventing and responding to oil spills, investments are made in ocean modelling; oil spill behavior; biological effects; containment; and cleaning techniques. The OPP also funds research to study the impacts of underwater noise and reduced availability of prey on marine mammals.

For more information: https://tc.canada.ca/en/initiatives/oceans-protection-plan

Looking Ahead - United Nations Decade of Ocean Science for Sustainable Development

On 5 December 2017, the United Nations proclaimed a Decade of Ocean Science for Sustainable Development, to be held from 2021 to 2030. In accordance with the direction from the United Nations General Assembly, the Intergovernmental Oceanographic Commission of UNESCO (IOC) has led preparatory and planning work. The Decade will provide a common framework to ensure that ocean science can fully support countries' actions to sustainably manage the Ocean and more particularly to achieve the 2030 Agenda for Sustainable Development. The Decade is described as providing a 'once in a lifetime' opportunity to create a new foundation, across the science-policy interface, to strengthen the management of our ocean and coasts for the benefit of humanity. The vision of the Decade is 'the science we need for the ocean we want'.

Through stronger international cooperation, the Decade will bolster scientific research and innovative technologies to ensure science responds to six societal needs:

- A ***clean ocean*** where sources of pollution are identified and removed
- A ***healthy and resilient ocean*** where marine ecosystems are mapped and protected
- A ***predictable ocean*** where society has the capacity to understand current and future ocean conditions
- A ***safe ocean*** where people are protected from ocean hazards
- A ***sustainably harvested ocean*** ensuring the provision of food supply
- A ***transparent ocean*** with open access to data, information and technologies

The UN Decade's Preparatory and Planning Phase, 2018-2020

The IOC has led the preparation of the Implementation Plan through a highly participatory and inclusive process that has spanned nearly three years. The process included a series of global, thematic, and regional planning meetings that convened over 1900 participants from the scientific community, governments, UN entities, NGOs, private sector, and donors across ten ocean basins between June 2019 and May 2020. The North Atlantic Regional Workshop was sponsored by DFO and hosted by the Ocean Frontier Institute in Halifax, NS in January 2020 where over 150 participants gathered from across the North Atlantic Region.

Next Steps under the Ocean Decade:
Individuals, scientific organizations and institutions, and nations are encouraged to prepare submissions to implement the UN Decade. During the preparation of submissions, the IOC encourages interested parties to consult and, where possible, collaborate with other institutions and partners working on common issues. Virtual sessions, that are open to global citizens, are planned in October and November 2020 to provide additional information on the Call. Decisions on endorsement under this Call will be made in the first quarter of 2021.

For more information: oceandecade.org

4. Overview of Canadian Ocean Science Networks and Initiatives

ArcticNet: ArcticNet was launched as a Network of Centres of Excellence (NCE) in 2003 and has had 3 renewals with total funding of $146.2 Million from 2003-2025. ArcticNet is the first and only NCE funded beyond the 14 year limit of NCE duration. The NCE ArcticNet has achieved high international visibility, especially the Arctic Change conference which has attracted upwards of 1,000 international participants.

ArcticNet represents Canada's largest commitment to date to explore the social, economic and environmental impacts of climate change and modernization on the Canadian North. While ArcticNet's origins in 2004 focused more on ocean research, over the years the NCE has successfully established the research, connections and experience to understand the broader challenges the North faces.

Through a network of partnerships, ArcticNet conducts inclusive research with and by northerners. With its recently refreshed science program, the Network offers services and initiatives that include:

- Enabling northern communities to lead their own research through the new ground-breaking NORTH BY NORTH Program;
- Combining multi-disciplinary scientific knowledge and local expertise to generate assessments and recommend how to adapt to change through the Integrated Regional Impact Studies (IRIS) and its new portal for knowledge mobilization;
- Promoting Canadian Arctic science excellence around the world with the SATELLITE Program.

Among the results: ArcticNet is redesigning a training toolbox to cultivate soft skills and nurture professional development for the 1000 HQP currently training with the Network. The Network is also pursuing new research partnerships with northern industry, in particular with the emerging Arctic Blue Economy based on fisheries, shipping and tourism.

ArcticNet is developing the Integrated Regional Impact Study (IRIS) Portal, ground-breaking new online technologies to facilitate the mobilization and transfer of the vast volume of science and

northern expertise acquired by ArcticNet and its partners. ArcticNet is also informing government on the management and preservation of key harvested species such as the Arctic charr and caribou, as well as on the management of drinking water supplies, among the most acute emerging issues in the North.

For more information:
https://www.nce-rce.gc.ca/NetworksCentres-CentresReseaux/NCE-RCE/ArcticNet_eng.asp

https://arcticnet.ulaval.ca/

Ocean Networks Canada

Ocean Networks Canada (ONC) monitors the west and east coasts of Canada and the Arctic to continuously deliver data in real-time for scientific research that helps communities, governments and industry make informed decisions about our future. Using cabled observatories, remote control systems and interactive sensors, and big data management ONC enables evidence-based decision-making on ocean management, disaster mitigation, and environmental protection. The observatories provide unique scientific and technical capabilities that permit researchers to operate instruments remotely and receive data at their home laboratories anywhere on the globe in real-time. Data are collected on physical, chemical, biological, and geological aspects of the ocean over long time periods, supporting research on complex Earth processes in ways not previously possible.

Most of ONC's work can be thought of as three major activity areas:

- Expanding the networks through installation, maintenance and repair of the physical sensor infrastructure;
- Intake of data, big data management and real-time reporting of ocean observations from thousands of sensors; and
- Both in-house and support for external research and development based on observations from ONC's sensor infrastructure.

An analysis of ONC's activities clearly shows strong complementarity with MEOPAR's current schedule of work, especially in the areas of data management and R&D. In fact, the two organizations have built strong connections including: partnering on several projects under MEOPAR funding, ONC's participation in the MEOPAR led Observations Core, and both are active players in the Canadian Integrated Ocean Observing System. Given their ongoing collaborations and regular interactions, it is safe to say that no duplication of effort is evident between them. While originating from opposite sides of the country (ONC – west coast, MEOPAR – east coast) both organizations work nationally and have impacts of national import.

For more information: https://www.oceannetworks.ca/

Ocean Frontier Institute

The Ocean Frontier Institute (OFI) was established in September 2016 with initial funding from the Canada First Research Excellence Fund (CFREF), and partner funding from provincial governments and partners. The initiative focuses on the North Atlantic Region and includes three primary Canadian partner universities – Dalhousie University, Memorial University and University Prince Edward Island. The OFI vision is to be a global leader in trans-national interdisciplinary ocean research, producing demonstrable and enduring social, economic, and environmental benefits. Through education, training, and communication — and by sharing talent, resources, and information — OFI generates ocean knowledge and opportunity.

OFI's Strategic Approach is highlighted under the following four areas:

Discover: Conduct research on the changing ocean and use the results to identify innovative solutions that advance the safe and sustainable development of the North Atlantic.

Collaborate: Engage stakeholders and rights holders in ocean management solutions and build support for ocean research and its applications

Lead: Advance ocean-related learning and teaching

Enable: Achieve OFI's vision through operational excellence

The Ocean Frontier Institute is focused on understanding key aspects of ocean and ecosystem change and developing strategic and effective solutions that can be applied both locally and globally. OFI's aim is to conduct research that advances policy decisions and advances the development of a blue — and sustainable — economy. The primary research areas include coastal communities and the ocean; the North Atlantic as a climate ocean; atmosphere – ocean interactions; marine safety; ocean data and technology; shifting ecosystems; and sustainable aquaculture and fisheries.

An analysis of the suite of OFI activities compared to those of MEOPAR shows that OFI has a more specific geographic region – the North Atlantic - and that OFI also has more specific funding recipients - three Atlantic Canada academic institutions. OFI has an international focus and has built strong international collaborations in this area. A strong area of collaboration achieved between MEOPAR and OFI has been via OFI's support for technical work conducted within the MEOPAR Observations Core initiative.

For more information: https://oceanfrontierinstitute.com/

Réseau Québec Maritime/ Quebec Maritime Network

The mission of the Quebec Maritime Network is to work in a spirit of close partnership and sharing of inter-sectoral knowledge to lead innovation and federate research players of the maritime sectors through a sustainable development approach. Their vision is to position Quebec as a world leader for all questions related to sustainable and responsible maritime development issues.

The scientific strategy of the Quebec Maritime Network is based on a global approach channeling Quebec expertise for the sustainable development of resources and environments of the St. Lawrence system with a focus on five themes:

- **Ecosystem Health:** This area establishes recurring inventories to document biotic and abiotic characteristics, determining the functioning, vulnerability, and nature of interactions between elements of socioecological systems, and monitoring their dynamics and evolution over time.
- **Human Community Health**: This area explores sustainable development and issues of governance, social cohesion, participation, ethics, and social, territorial, and intergenerational equity issues.
- **Monitoring, Security and Maritime Safety**: This thematic area covers a wide range of issues such as human health and safety, environmental protection, and monitoring maritime facilities and infrastructures, for all maritime activities such as navigation, resource exploitation, and tourism.
- **Sustainable and Intelligent Maritime Transport**: This research theme concerns the development of new maritime technologies as well as the analysis and improvement of existing practices and procedures, including logistics networks for maritime transport and the organization of port systems.
- **Resources, Marine Energies and Health of the Maritime Economic Sector**: This theme includes a review of current practices to exploit resources of the St. Lawrence System (including energy, fisheries, maritime transport and cruises), the development of new processes, approaches, and procedures, and/or the exploration of new and hitherto unconsidered maritime resources.

Réseau Québec Maritime as described in its vision, mission and scientific strategy has chosen to focus its work on the Saint Lawrence watershed. It is key to note that RQM funding is restricted to Quebec-only institutions. An analysis of the project activities clearly shows a complementarity with that of MEOPAR. The two organizations have partnered on several projects and given their ongoing collaborations and regular interactions, particularly on the Observation and Prediction Core activities, it is safe to say that no duplication of effort is evident between them.

For more information: http://rqm.quebec/en/rqm-research/

Ocean Tracking Network

The Ocean Tracking Network (OTN) is a global aquatic animal tracking, technology, data management and partnership platform headquartered at Dalhousie University in Canada. OTN and its partners are using electronic tags to track more than 200 keystone, commercially important, and endangered species worldwide.

OTN's vision is to revolutionize the understanding and stewardship of aquatic species globally

through collaborative leveraging of Canadian and international expertise, data warehousing and technological innovation.

OTN's mission is to inform the sustainable management and stewardship of aquatic animals by providing knowledge on their movements, habitats and survival in the face of changing global environments.

MEOPAR works in collaboration with the OTN, in specific areas of technical expertise such as the use of ocean gliders as a technology for ocean observation, in sharing of infrastructure, and in better understanding of the movements of marine mammals and other aquatic animals in the vicinity of marine transportation. Through the activities of the Observation Core, strong connections have been made between MEOPAR and OTN.

For more information: https://oceantrackingnetwork.org/

Ocean Supercluster

Canada's Ocean Supercluster (OSC) is intended to grow the ocean economy in a way that has never been done before, where industry leaders from multiple ocean sectors come together to develop and commercialize solutions to shared ocean challenges, while advancing Canada's position as a global leader in ocean.

OSC is an industry led initiative with members from over 300 industry and associate members across 13 ocean industries across the country who are committed to working together. Members have a shared interest in solving ocean challenges, developing, attracting and retaining talent, improving supply chain opportunities, doubling the number of ocean tech start-ups to strengthen the innovation ecosystem and growing Canada's ocean economy. Industry members are private sector firms who make a cash investment. These members include the fishery, aquaculture, offshore resources, shipping, defense, marine renewables, marine bio-products and ocean technology. They develop Technology Leadership Projects, leverage their investment with matched funds from the Supercluster, while supporting Innovation Ecosystem activities. Associate members include private sector firms, not-for-profit corporations, Indigenous organizations, post-secondary institutions and other organizations with an interest in ocean innovation, who can develop, make in-kind investments and participate in Technology Leadership Projects and Innovation Ecosystem activities.

For more information**:** https://oceansupercluster.ca/

Canadian Operational Network of Coupled Environmental PredicTion Systems

The Canadian Operational Network of Coupled Environmental PredicTion Systems (CONCEPTS) is a collaboration between Fisheries and Oceans Canada (DFO), Environment and Climate Change Canada (ECCC) and the Department of National Defence (DND). The network works to develop and implement computer models that support ocean-ice forecasting advancements.

The aim is to take advantage of improvements in ocean models and new real-time global oceanographic observation systems to produce oceanographic forecast products and improve seasonal to inter-annual climate forecasts.

MEOPAR has linkages to the CONCEPTS prediction initiative through their respective researchers as well as having DFO and ECCC departmental members on the Research Management Committee. The recent MEOPAR-led Tracer Release Experiment conducted in the Gulf of St Lawrence is an example of the scientific expertise from MEOPAR and CONCEPTS working together.

For more information: https://www.ic.gc.ca/eic/site/063.nsf/eng/h_97620.html

Canadian Integrated Ocean Observing System (CIOOS)

The Canadian Integrated Ocean Observing System was established in 2019 as an online open-access platform designed for sharing reliable and high-quality data and information on the state of our ocean. This nationally coordinated system brings together a consortium of partners in the Pacific, St. Lawrence, and Atlantic regions including the Ocean Frontier Institute, Dalhousie University, the Coastal and Ocean Information Network Atlantic, the Marine Institute of Memorial University of Newfoundland, the Ocean Tracking Network, the St. Lawrence Global Observatory, the Tula Foundation, the University of Victoria and Ocean Networks Canada to implement the first phase of CIOOS.

This national collaboration will make ocean data around the country findable, accessible, interoperable and re-usable, leveraging existing Canadian and international ocean observation data into a national system. This objective will be achieved through a federated structure with regional associations providing a local nexus of data management expertise for, and engagement with, local data producers and data consumers. Three regional associations have been established in the Atlantic, Gulf of St Lawrence and Pacific regions. The RAs actively support ocean science and management as well as promote collaborative opportunities among ocean sectors across Canada. CIOOS responds to user needs enabling them to share, discover, access, visualize, and download data.

At the global level, CIOOS is the regional player contributing to the Global Ocean Observing System a programme that is executed by the Intergovernmental Oceanographic Commission (IOC) of the UNESCO, but its success relies on the coordinated contributions of several people and organizations worldwide. From a governance perspective, there are three discipline-based GOOS Expert Panels that provide scientific oversight on Physics and Climate, Biogeochemistry, and Biology and Ecosystems. These expert Panels are central in the GOOS work structure, as they focus on the dispersed GOOS Networked observations, acting as a liaison and advocate for users and collaborators at local, national, and regional scales.

Another important aspect of the global programme are the GOOS Regional Alliances (GRAs) that identify, enable, and develop sustained GOOS ocean monitoring and services to meet regional and national priorities, aligning the global goals of GOOS with the need for services and products satisfying local requirements.

The development of CIOOS has been a joint initiative between Fisheries and Oceans Canada and MEOPAR, with both organizations providing financial resources and key ocean observing expertise. The MEOPAR Observation Core, in particular, has been influential in guiding CIOOS in this Phase 1 of development. In regards to financial support, in 2019, Fisheries and Oceans announced an investment of $1.5 million per year for two years to support CIOOS. An additional $2 million over four years was provided by MEOPAR.

For more information: https://cioos.ca/ and https://www.goosocean.org/

OceanCanada Partnership

The *OceanCanada* Partnership is a 6-year research initiative (2014-2020) funded by the Social Sciences and Humanities Research Council of Canada (SSHRC). The Partnership is currently comprised of 19 formal research partners, including universities from coast to coast to coast, community organizations and Fisheries and Oceans Canada.

The central goals of *OceanCanada* are to understand and address threats facing Canada's Arctic, Atlantic and Pacific coastal-ocean regions and seek opportunities to develop a shared vision for the future of our ocean – one that promotes the health and well-being of people living on coasts as well as the marine environment. *OceanCanada*'s initiative is highly interdisciplinary, and their research integrates a wide range of expertise from many fields of study, including economics, law, geography, ethics, fisheries science and oceanography.

A strength of their partnership lies in the goal of integrating insights from across these broad fields with local and traditional knowledge in order to help inform policies at the regional and national levels that are responsive to community needs. It is believed that such a holistic view is necessary for developing policies that reflect a shared understanding of emerging threats, challenges and opportunities.

A key objective of the *OceanCanada* partnership is to integrate knowledge across academics, community stakeholders, and organizations (private and public sectors) and offer a new avenue for data sharing, cross-fertilization of ideas, co-creation of knowledge, and collaborative building of research and governance capacity for the benefit of both current and future generations of Canadians. The network is organized with Regional Working Groups (Arctic, Pacific and Atlantic); as well as National Working Groups (Law and Policy, National Data and Integrated Scenarios, and, Knowledge Mobilization). In an effort to integrate across these working groups, three cross-cutting themes exist on the topics of - Access to Resources, Governance, and Changing Oceans, all in the context of ocean health and community wellbeing.

For more information: https://oceancanada.org/

Community Conservation Research Network

The Community Conservation Research Network (CCRN) is an international initiative to study and support local communities in their efforts to engage in environmental conservation that sustains local livelihoods, and to encourage best practices of governments to support these community initiatives. The CCRN is a partnership of Indigenous, community, university, governmental and nongovernmental organizations, with a headquarters in Halifax. The network works globally through the website below to provide a focal point and resource centre on the themes of Communities, Conservation and Livelihoods. The website provides a global learning and resource platform - highlighting local communities conserving their environment and sustaining their economy. The platform provides a range of resources from around the world, including communities' stories, videos, webinars and animations, conference presentations, informative guidebooks and an interactive community map. The CCRN also undertakes local-level community-based research and capacity building activities at sites around the world. Using a consistent social-ecological systems lens, the CCRN's research is producing a range of insights on such themes as environmental governance, Indigenous self-governance, local network and the success of conservation initiatives. These insights provide guidance for communities, policy makers and decision makers at all levels, from local to global. A key goal is to empower communities to enhance their natural environments and local economies for decades to come.

The CCRN is a strong network of many world-leading international scholars, together with a diverse set of Canadian governmental, nongovernmental and community-based partners. Also key to the network is the training of a new generation of researchers with capabilities in the CCRN's research methods and expertise in exploring our communities, conservation, livelihoods and policy themes.

For more information: www.CommunityConservation.net

Too Big to Ignore

Too Big to Ignore (TBTI) is a global research network and knowledge mobilization partnership that focuses on addressing issues and concerns affecting viability and sustainability of small-scale fisheries (SSF). TBTI has more than 400 researchers and 20 organizations from approximately 45 countries around the globe. The partnership is organized around 14 research clusters, addressing a wide range of economic and social issues. Within Canada, key supporting organizations are the Social Sciences and Humanities Research Council of Canada; C-CORE, Memorial University, and the Marine Institute.

The TBTI objectives are to: understand the importance of SSF to livelihoods, poverty alleviation, and food security; explore SSF contribution to economic development, sustainability, and community viability; improve policy discussions and decision-making about SSF; strengthen

knowledge about SSF and build capacity in research and governance; and, advance implementation of the Voluntary Guidelines for Securing SSF in the context of food security and poverty.

Their work involves: facilitating networking opportunities; organizing meetings, workshops and webinars; developing capacity in transdisciplinary research; connecting sciences to policy and society; producing books, papers, reports and briefs; and, hosting the World Small-Scale Fisheries Congress.

For more information: http://toobigtoignore.net/

Pacific Institute for Climate Solutions

The Pacific Institute for Climate Solutions (PICS) is a collaborative and user engaged institute that convenes solution seekers and research partners to co-design, co-develop and co-deliver impactful climate solutions for British Columba, Canada, and potentially the world.

PICS was launched in 2008, as the first-of-its-kind climate research collaboration amongst four research universities in British Columbia - University of Victoria, Simon Fraser University, University of British Columbia, and the University of Northern British Columbia. It was established through a major endowment from the Government of British Columbia and has operated as an independent, non-partisan organization that is policy neutral, and technology neutral.

The aim of PICS is to have solution seekers—decision makers within government, industry, and our communities— to not only use and benefit from PICS research, but help design it in the first place. PICS supports research that will help transform the economy and communities to become net-negative carbon emitters, while being ready for the opportunities and challenges of a changing climate. PICS responds to the evolving complexities of climate change adaptation and mitigation needs by connecting experts in partnerships that pursue cutting edge research and implement solutions.

For more information: https://pics.uvic.ca/

Canadian Ocean Literacy Coalition

The Canadian Ocean Literacy Coalition (COLC) is an alliance of organizations, networks, institutions, and communities working together to better understand and advance ocean literacy in Canada. Widely accepted internationally, ocean literacy is defined as understanding our impact on the ocean and the ocean's impact on us.

At the global level, following the 2017 United Nations (UN) Ocean Conference, UNESCO recognized the importance of helping citizens understand, appreciate, and care for the ocean. Known as ocean literacy, this civic relationship with the ocean involves understanding our

impact on the ocean and the ocean's impact on us. Ocean literacy is a growing global priority. It has been included as a strategic objective for the 2021–2030 UN Decade of Ocean Science for Sustainable Development.

In Canada, there is a growing interest in ocean literacy. For coastal communities, Indigenous people, aquaculture companies, small-scale fishing communities, and ocean industries the ocean plays an essential role in their daily lives. This connectedness to the ocean is directly linked to livelihoods, food security, and socio-cultural well-being. The ocean also plays a critical role in the overall well-being of all Canadians, even those 27 million+ living inland.

The COLC's primary project since their inception in 2018 has been to lead a Canada-wide research initiative to better understand Canadians' varying relationships with the ocean and to examine how ocean literacy (OL) is understood and practiced across different regions and sectors. The aim of this work is to establish a baseline seascape of OL in Canada, and in so doing, to co-develop an evidence-based national OL strategy and implementation plan.

The COLC has three key objectives:

1. Build a national ocean literacy strategy through regional consultation and engagement.
2. Establish and support an active ocean literacy research and monitoring program for Canada.
3. Strengthen ocean literacy initiatives and joint activities of COLC member organizations that promote broad public engagement across Canada.

For more information: https://colcoalition.ca/

Canadian Meteorological and Oceanographic Society (CMOS)

With the mission of advancing meteorology and oceanography in Canada, the Canadian Meteorological and Oceanographic Society (CMOS) was created in 1967. Originally called the Canadian Meteorological Society, CMOS took its current name in 1977. Over five decades later, this national society remains dedicated to promoting meteorology and oceanography in Canada, and is a major non-governmental organization serving the interests of meteorologists, climatologists, oceanographers, limnologists, hydrologists and cryospheric scientists in Canada. CMOS currently boasts 700 members and subscribers, that include students, corporations, institutions, as well as representatives from the private sector and government.

CMOS supports a number of national, knowledge mobilization activities including:

- The international, peer-reviewed journal Atmosphere-Ocean which publishes results of original research, survey articles, notes and comments on published papers in all fields of the atmospheric, oceanographic and hydrological sciences, including both applied and fundamental research contributions in English or French.
- The CMOS Bulletin, published since 1967, covers news, perspectives and articles on the latest

research and technology developments in meteorology, oceanography and climatology. It is now published on-line, in an open access format.

- The CMOS Congress. This annual congress is a major event, attracting hundreds of researchers from across Canada and the world. The themed congress moves from city to city across Canada, each year.
- CMOS Speaker Tour. A prominent Canadian researcher is supported to present a talk and visit research institutions across Canada.

CMOS's latest strategic plan outlines three main goal areas to enhance the effectiveness of the organization:

1. **Members** Promote membership with CMOS by demonstrating its relevance and benefits to members, and honouring outstanding service to Canada in the field of meteorology and oceanography.
2. **Outreach** Foster additional outreach and communications activities to increase the visibility of the CMOS "brand" and promote meteorological and oceanographic science
3. **Education** Foster meteorological and oceanographic engagement among Canadians by supporting improvement and strengthening of meteorological and oceanographic education at all levels.

CMOS and MEOPAR have close ties, with many MEOPAR researchers playing active roles in CMOS. The 52nd CMOS Congress, held in Halifax in 2018, was coordinated with MEOPAR's Annual Science Meeting and Annual Training Meeting and included joint sessions.

For more information: https://www.cmos.ca/index.html

Hakai Institute

The Hakai Institute is part of the Tula Foundation, and conducts long-term scientific research at several locations on British Columbia's coast, using technology and science to better understand the coastal margin of the region, and beyond. Founded in the early 2000s, it currently maintains ecological observatories on Quadra Island and Calvert Island and has offices and a laboratory in Victoria. The Hakai Institute represents "what happens when the elements of funding, infrastructure, science programs, skilled staff, and partners are integrated into one organization." As a solution to a lack of infrastructure, the Hakai Institute purchased a former fishing lodge in Calvert Island in 2009. A second Hakai ecological observatory was established in 2014 on Quadra Island, and since then the institute's scientific activities have stretched along the BC coast, reaching both Washington and Alaska. In 2015, the Tula Foundation launched Hakai Magazine, a digital publication exploring science, society, and the environment from a coastal perspective.

The Hakai Institute added the Hakai Node at the University of British Columbia's Institute for Oceans and Fisheries to its fleet in 2017, and 2018 saw Quadra Island's Marna Lab (for shellfish, ocean acidification and genomics research) come to life. Along with this growth, the Hakai

Institute continues to add expertise in technology, including sensor networks, geospatial mapping, information technology, and computer modeling. Since 2019, Hakai has worked in partnership with Ocean Networks Canada to build the Pacific node of new Canadian Integrated Ocean Observing System (CIOOS), working closely with Fisheries and Oceans Canada (DFO), MEOPAR and partners both locally and across the country.

For more information: https://www.hakai.org/about/

Quebec-Océan

A long-standing, inter-institutional oceanographic research group linking members from six Quebec universities and additional partners involved in ocean research in Quebec, Québec-Océan combines expertise, resources and diverse approaches to studying the ocean and its challenges. Carrying out research projects on both regional and international scales, Québec-Océan's mission is to "foster the mobilization of Quebec researchers and the training of students to ensure excellence in oceanographic research and the dissemination of knowledge."

The group's research themes include:

- Ocean responses to global change
- Integrity of coastal marine environments and regional socioeconomic issues
- New frontiers in oceanography

The training of graduate students in an important part of Québec-Océan with the centre offering a multidisciplinary framework to its trainees, ensuring access to experts inside and outside of the lab. Quebec-Ocean holds an annual scientific meeting which has special events for early career researchers. It publishes a newsletter three times per year and has a regular seminar/ webinar series.

For more information: http://www.quebec-ocean.ulaval.ca/

Canadian National Committee for SCOR (CNC/SCOR)

The Scientific Committee on Oceanic Research (SCOR) is the leading international non-governmental organization for the promotion and coordination of international oceanographic activities. Scientists from 36 nations participate in its working groups and committees. While it does not fund research directly, SCOR's activities focus on promoting international cooperation in both planning and conducting oceanographic research, as well as solving the problems and challenges that impact this research.

Countries gain their membership in SCOR through national committees, hence the Canadian National Committee for SCOR (CNC/SCOR). Canada became a member of SCOR shortly after it was founded in 1957 and its membership is jointly supported by Fisheries and Oceans Canada (DFO) and the National Research Council of Canada (NRC).

The advantages of Canada's membership in SCOR include:

- The opportunity to comment on proposals for scientific activities as they develop
- The opportunity to assist in the formulation of international scientific priorities
- The opportunity to encourage the involvement of Canada's scientists in these international efforts
- Increased exposure of Canada's scientists to international ocean science activities and the increased likelihood of their participation in working groups and other SCOR activities.

For more information: https://cncscor.ca/site/background/CNC

5. Ocean Science Alliances

Marine Alliance for Science and Technology for Scotland

The Marine Alliance for Science and Technology for Scotland (MASTS) consists of a consortium of over 15 Member and Associate Member institutions. MASTS plays an important role in fostering collaboration amongst its members to ensure that they benefit from being part of a nationally and internationally respected organization. Furthermore, it is recognised as a national body which brings together the majority of Scotland's marine science capacity and can offer a collective voice for a significant proportion of that community.

MASTS has been accepted as one of the three UK organisations represented on the European Marine Board, a key organization for marine sciences in this region. Through this membership, MASTS can engage with other European partners and the European Commission. In addition, this membership provides MASTS with opportunities to influence EU calls for funding, inform Commission thinking on a range of marine related issues and be party to strategic initiatives with third-party countries favoured as partners by the EU.

A major objective of MASTS is to enhance the Scottish marine research environment through improved co-ordination and collaboration. To achieve this, the MASTS Executive Committee has established three major themes to organise the research of the MASTS community. These themes (Dynamics and Properties of Marine Systems, Productive Seas, and Marine Biodiversity, Function and Services) also strongly reflect the Marine Policy and the current research agenda of the Scottish Government, provide strategic oversight, and are cornerstones for high level representation, networking and horizon scanning.

MASTS promotes the following primary goals:

- To enhance scientific excellence in marine research through communication,

collaboration and co-ordination within the Scottish marine research community
- To support a healthier environment as a result of better informed policies to manage human activity based on the best available scientific knowledge
- To enhance Scotland as a world player in marine science through the delivery of scientific excellence in the field of marine science
- To raise public awareness of the value and heritage of Scotland's marine environment
- To promote wealth creation and environmental protection facilitated by sound science in supporting industries such as renewable energy, marine fisheries and aquaculture
- To help establish an economy able to plan for the effects of climate change
- To provide experience and training to the next generation of marine researchers and opinion makers through the MASTS graduate school and related bespoke events

In terms of financial resources, the Scottish Funding Council, together with the original MASTS member institutions, made an initial 5-year investment of approximately £75M to develop MASTS in 2009. MASTS has been renewed (Phase 2) for an additional five years through until July 2022 with the majority of funding now coming from its Member organizations. This pooling of marine research talent has a constituency of more than 750 researchers with the management of resources consisting of over £66 million annually. They continue to work towards becoming self-supporting as an independent entity beyond the SFC funding period.

As a consortium or "alliance" of over 15 marine research organizations, MASTS has successfully brought together its national organizations, enabling them to not only collaborate amongst its members but to also present a unified face to regional and global marine research efforts. The alliance has gained a positive reputation in marine research, enabling it to have a voice of influence. At the global scale, Memoranda of Understanding have been signed at the bilateral level with international science initiatives including MEOPAR.

For more information: https://www.masts.ac.uk/

German Marine Research Consortium

The German Marine Research Consortium (Konsortium Deutsche Meeresforschung -KDM) was formed in 2004 and currently has a membership of 20 organizations from research institutions, universities and non-university institutes and museums, and one Federal authority, which are engaged in marine, polar and coastal research. KDM brings together the marine science expertise from across its member institutions and collectively presents it to policy makers and research funding organisations as well as to the general public.

The Alliances major goals are:
- The advancement of science and research, in particular in the field of marine sciences including polar and coastal research;
- to foster the collaboration of our member institutions and the development of joint research programmes;
- to intensify cooperation with German, European and international marine research

partners and the use of infrastructure and large equipment; and
- to collectively represent the interests of marine research towards decision-makers in Germany and the European Union as well as towards the general public.

The primary activities amongst the Alliance partners are:
- Research planning: identification of future research fields and the coordinated use of shared infrastructure;
- Research development**:** development of research strategies within a European and global context as well as recommendations to decision makers and research programming;
- Infrastructure management: the creation, management and development of a national pool of research vessels and underwater vehicles, instrumentation and observatories;
- International cooperation: representation within international bodies and the fostering of cooperation with international partners;
- Communicating marine science: d**i**alogue with the public, with decision makers in government and industry to raise awareness about marine research.

KDM has developed Strategy Groups (e.g. marine biodiversity, coastal research, marine biological resources, mineral resources, observatories, ocean in the climate system, and social science) that are dedicated to overarching marine scientific topics, in particular those with a high societal relevance. They are mandated to develop the strategic focus of the marine science topics, and to contribute to the orientation of emerging funding lines. Furthermore, they prepare policy advice in their respective fields and act as counterparts for decision makers. In addition, the Strategy Groups collaborate closely with the German Research Council, in particular the Senate Commission of Oceanography. They ensure the inclusion of scientific fields other than natural sciences, and of marine scientific working groups at institutions which are not KDM members.

The consortium provides a central location to obtain information relating to 18 different marine science academic studies at institutions across Germany. In addition, marine science summer school opportunities are promoted by the organization. KDM also hosts a portal that provides a platform for scientists working at publicly funded research institutions to submit cruise proposals for the research vessels.

For more information: http://www.deutsche-meeresforschung.de/

German Marine Research Alliance

In 2019, the German marine research community, together with the federal government and the northern German states of Bremen, Hamburg, Mecklenburg-Western Pomerania, Lower Saxony and Schleswig-Holstein, founded the German Marine Research Alliance (Deutsche Allianz Meeresforschung - DAM). This alliance links leading German marine research institutions in order to contribute to a sustainable use of the ocean and seas. DAM represents

one of the world's largest marine research alliances with nineteen current members and associated members from university and non-university marine research institutions.

The objectives of DAM are to strengthen the sustainable use of the coasts, seas and the ocean through research, data management and digitalisation, infrastructure and transfer of knowledge. To this end, the DAM is working together with its member institutions to develop solution-oriented knowledge and to communicate potential courses of action to politics, business and civil society.

Core Areas of Work:

Research: Knowledge for Decision-Making

The DAM's research missions will be transdisciplinary and focus on current and relevant challenges facing society in marine research, allowing science-based decisions to be made for the protection and sustainable use of coasts, seas and the ocean with clear objectives. To achieve this, relevant non-university research institutions and universities are cooperating and coordinating their existing activities. Two topics have been selected for now: Protection and sustainable use of the ocean: Options, concepts and strategies and Marine carbon sinks: Contributing to climate protection.

Data Management and Digitalization: Strategies for Marine Research

Together with its member institutions, the DAM is developing an integrated and reliable data management concept for the research environment. It supports open access to marine research data in line with FAIR principles (findable, accessible, interoperable, and reusable). The aim is to generate added value for science and innovation through open access and by integrating quality-assured research data across disciplinary boundaries. This will be done taking into account the activities of the National Research Data Infrastructure – another initiative of the DAM.

Working within a network of non-university research institutions and universities and maintaining a close dialogue with them, while also taking into account the mission of the Helmholtz Association, the DAM is developing standards that facilitate access to and use of decentralised data sets. The aim is to integrate but also to consolidate existing repositories and joint services and to strengthen links with national, European and international platforms.

Pilot Project: Underway Research Data: With its pilot project Underway Research Data, DAM has begun the task of bringing together the data management activities of its member institutions with regard to "underway data". The aim of the pilot project is to exploit the full potential of German research vessels as mobile measuring platforms. Permanently installed sensors are continuously collecting valuable data, which has until now not been systematically checked for quality and sustainably made available. Workflows will now be developed and established in the community to ensure that quality-controlled underway data is shared in line with FAIR principles. At the same time, the German Marine Research Portal will be expanded to simplify access to and the

visualization of marine research data. The DAM office will coordinate the networking and harmonization together with the middle management of the member institutions.

Infrastructure: Concepts for Efficient Use
German marine research has a unique research infrastructure, including research vessels and research stations, underwater vehicles, observatories and aircraft. The DAM develops comprehensive utilization and operational concepts to facilitate the efficient use of this infrastructure. Operating the infrastructure remains the task of the individual institutions.

Transfer: Using Knowledge Effectively for Politics, Business and Society
Scientific knowledge can impact society when it leads to innovations, developments, decision-making or an increase in knowledge beyond the scientific community. At the same time, the dialogue with non-scientists allows socially relevant questions and views to be incorporated into current research. This is why the transfer of scientific findings to politics, business and society is one of the DAM's key objectives. The DAM pools German marine research expertise concerning the sustainable management of the coasts, seas and the ocean and ensures that knowledge is exchanged in ways that are appropriate to the target group. The DAM also develops strategies for cooperating with business, promoting young scientists and for capacity development. In addition, through its transfer activities, the DAM contributes to the promotion of ocean literacy.

For more information: https://www.allianz-meeresforschung.de/en/

Centre for Ocean Ventures & Entrepreneurship

The Centre for Ocean Ventures & Entrepreneurship (COVE) is a collaborative facility for applied innovation in the ocean sector. Its mission is to propel the ocean economy by providing high quality marine infrastructure and a collaborative space in which a community of ocean enterprises can start, grow and prosper. Their primary goal is to support ocean technology commercialization.

Located in what was once the Canadian Coast Guard facility on Halifax Harbour, this hub provides a site for local and global ocean technology businesses, post-secondary institutions, researchers, and marine-based and service businesses that support the ocean sector. The COVE site features extensive marine facilities with two large, deep-water piers, office space, an incubator and space for shops and labs.

COVE brings together the ocean tech community to push ocean tech advances to market. It's a space that fosters innovation and cross-pollinates expertise, ideas, and resources among members. COVE is where business growth, opportunity, and technical advances happen.

Members have access to shared equipment and infrastructure, and the resources of the management team to nurture partnerships in forming technology leadership projects. As well, with initiatives and a site designed to encourage formal and informal networking, COVE members can connect with the people, companies, and opportunities essential to grow their business.

The advances that are developed through COVE will have practical, commercial and revolutionary applications in ocean tech. There is a global need for ocean tech solutions. The impact of what happens at COVE has local, provincial, national and international significance.

An analysis of COVE activities, membership and focus of work indicates no overlap with the activities of MEOPAR. Given the "ocean tech" focus of COVE, however, there is strong complementarity between COVE's activities in developing and improving ocean technology and the Observation Core of MEOPAR's ongoing program of work in utilizing data from ocean technology. The MEOPAR Observation Core supports, develops and coordinates ocean observation capacity for MEOPAR projects and closely-related activities of partners. The functions are to:

- support shared access to observing infrastructure, and encourage technological developments;
- maintain and deploy technical expertise for ocean observation in strategic locations;
- share knowledge and training related to ocean observation; and
- promote national and international sharing of data, expertise and the coordination of observation programs.

For more information: https://coveocean.com/

Canadian Water Network

Canadian Water Network is included in this Assessment Report, less for the scientific content of the Network but more for the evolution and current composition of the Network itself. It originated as a Networks of Centres of Excellence and has successfully transitioned to a new non-profit entity.

The Canadian Water Network was established in 2001, in response to Walkerton, Ontario's deadly drinking water crisis. Over the next 16 years, the organization invested more than $100M in water research as a Network of Centres of Excellence. The organization is now an independent non-profit that serves decision-makers across the water sector.

The Network draws on a broad base from government, academia, NGOs and industry to articulate key water challenges, share knowledge and practice insights, discuss effective strategies and build partnerships. It identifies six interest areas: municipal water; agriculture and water; climate change; energy and resources; watershed management; and, Indigenous communities.

A key aspect of the Network is the Canadian Municipal Water Consortium that connects

utilities, municipalities, researchers, industry, government and other organizations to address Canada's municipal water management challenges. The Consortium is led by a "Leadership Group" of 22 municipalities who represent senior decision makers from municipalities and utilities across the country. The Consortium also has "General Members" who contribute to or collaborate on national initiatives, exchange knowledge with peers, expand their network of contacts, and access leading knowledge. This group includes utilities, municipalities of all sizes, academic institutions, industry, provincial and federal governments, and other water-related organizations. They also connect with and support emerging water leaders through their Student and Young Professional program who organize networking events across Canada, host national webinars, represent #CWNSYP on social media and participate in the Blue Cities conference.

Each year, the Consortium undertakes national initiatives that accelerate, advance and improve municipal water management decisions. The Network addresses topics such as Contaminants in wastewater, Improving Flood Risk Evaluation and other issues by working through expert panels, national surveys and workshops that result in Synthesis Reports, Government briefings, and presentations to utility leaders across Canada, stakeholder meetings and pilot projects.

Finally, the Canadian Water Network is one of twelve members of an international water research alliance, The Global Water Research Coalition. Focusing on water supply, wastewater issues and renewable water resources, the GWRC is dedicated to promoting international cooperation and collaboration in water-related research.

For further information: https://cwn-rce.ca/

6. Research Vessel Capacity Challenges

Context

Ocean-going research vessels are a key component of marine science research infrastructure. Vessels and their associated equipment play a key role in supporting and enabling ocean and coastal research and monitoring activities. Within Canada and at the international level, challenges such as aging fleet and equipment, and increasing costs of operation, are facing this critical infrastructure.

Recently completed and planned new builds under the National Shipbuilding Strategy are sufficient only to replace retiring CCG vessels required by the Department of Fisheries and Oceans for its fishery, ecosystem management and science mandate. In addition, new Arctic and Offshore Patrol Vessels (AOPS) are currently being delivered which may be able to provide limited scientific capacity to researchers. There are growing needs of non-government sectors (e.g. academia, Provincial governments, industry and non-government organizations) for vessel time across Canada which cannot be met with the current suite of research vessels. There are now serious limitations in terms of geographical/ temporal availability of vessels, flexibility of use, and multisectoral access to available capacity.

The costs to access and operate both the current and new research vessels continues to increase and is experienced by both international and domestic scientists. It is challenging for academic researchers to be able to acquire time aboard Canadian research vessels and to obtain the necessary ocean research and monitoring equipment. In response to these needs, several initiatives have been launched at the international level and within Canada to better understand the current status of research vessels fleet (age, condition, etc.), their capabilities and equipment, and their ability to support priority science needs.

International Initiatives

At a global level, the European Marine Board is an example of an organization that has recognized the challenges discussed above and who has issued a series of Position Papers that studied the challenges of a dynamic, current and fully accessible research fleet over the past years. These papers have addressed why research vessels are needed, explaining the multiple roles they play in supporting marine science and ocean observing. The papers also presented an overview of the current European fleet and its capabilities, including specialized capacity to conduct research in deep-sea and Polar regions. In addition, the work also outlined the concerns around training for vessel crew, marine technicians and shore-based staff.

Another example of an international initiative that has recognized the lack of access to, and expense of operating, research vessels is the Arctic Research Consortium (ARICE) a project financed by the European Union Horizon 2020 funding program. ARICE joins the efforts of 14 partners from 12 different countries (Germany, Sweden, United Kingdom, Norway, Iceland, France, Italy, Poland, Finland, Denmark, Canada and the United States of America). The project started in January 2018 as an international cooperation strategy aiming at providing Europe with better capacities for marine-based research in the ice-covered Arctic Ocean. ARICE endeavors to better coordinate the existing polar research fleet, by offering transnational access through a "call for ship-time proposals" to a set of six international High Arctic research icebreakers and by collaborating with maritime industry in a "programme of ships and platforms of opportunity".

Canadian Initiatives

To help better define and address this problem, MEOPAR has established a National Research Vessel Task Team with representation from end-users and other interested parties across Canada. The Task Team will develop a vision for the medium to long-term (5-20 years) future of Canada’s vessel needs for both coastal and offshore research, while proposing practical solutions to address the immediate capacity crisis. It will focus especially on the larger vessels required for offshore research and include consideration of the needs of users in academia and the private sector as well as different levels of government.

As part of the work of the Task Team, the following three possible solutions have been identified to the research vessel capacity crisis:

a) **Build and operate more dedicated, specialized research vessels** – this option may be unrealistic given the scale of the need across Canada. Further, it would take years to realize, and involve massive cost as well as a major, long-term commitments to support that might outstrip the ocean research community's capacity. It also would be inconsistent with the National Shipbuilding Strategy, which only now has begun delivery of new ships to the CCG and Royal Canadian Navy.

b) **Rely on cooperation with foreign nations/ institutions and their vessels via shared cruises and/or charters** – this option is used increasingly, by default, by academic, private-sector and government users. It has some advantages in mitigating near-term deficits, but has several disadvantages over the medium-to-longer term. The disadvantages include dependence on foreign countries, which in turn risks restricting Canada's sovereign ability to access its own waters for research and pursuit of Canadian priorities. The ability to charter or share a foreign vessel may involve legal and financial arrangements beyond the reach of many Canadian institutions and could risk legal challenge from Canadian ship operators. Use of foreign vessels typically involves long transits for repositioning, which limits flexibility and raises costs. Sharing of vessels could involve legal restrictions on Canadians (e.g. involving intellectual property or publication rights). Access to foreign vessels will, typically, be restricted by the priorities of the foreign owners, which might limit Canadians' vessel access to times of year with less interest/demand.

c) **Develop Modular Ocean Research Infrastructure (MORI)** for use with available, "workhorse" industry vessels as well as future CCG ships and naval AOPS, in order to convert them into sophisticated research vessels on a temporary, as-needed basis. This MORI option is original and would require fundamentally new approaches, but represents a scalable, flexible solution to vessel availability that might work well for Canada. It is compatible with flexible scientific use of Arctic and Offshore Patrol Ships and offers options for Canadian private sector involvement. Significantly, the MORI concept could alleviate Canada's ocean-going research vessel capacity crisis in the near future, through use of existing and planned, capable vessels that are Canadian owned and operated. This option would require a national approach for accessing and coordinating vessel time and MORI infrastructure, however such a system is probably required whatever solutions are implemented.

   Furthermore, there are potential commercial opportunities associated with the development of the MORI option. The ability to have mobile research infrastructure that could be placed on workhorse vessels offers a means of supporting modern ocean research by many countries worldwide that do not currently have access to specialized research vessels, including developing countries. Successful demonstration in Canada of a fully developed MORI concept could open commercial possibilities for deployment of the concept in other markets worldwide.

For further information:

www.tpsgc-pwgsc.gc.ca › mer-sea › sncn-nss › index-eng
https://www.marineboard.eu/european-research-vessels
http://www.europeanpolarboard.org/activities/scientific-initiatives/arice/
http://www.ervo-group.eu/np4/home
https://bulletin.cmos.ca/modular-ocean-research-infrastructure/