Canadian Ocean Decade Workshop

MAY 12-13, 2021

SUMMARY REPORT

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EXECUTIVE SUMMARY

The 72nd Session of United Nations (UN) General Assembly proclaimed that 2021-2030 would be the **UN Decade of Ocean Science for Sustainable Development 2021-2030** (referred to as 'the Ocean Decade'). The Ocean Decade is a global effort that aims to transform ocean science to reverse the decline in ocean health and ensure a sustainable ocean for future generations. In preparation for the Ocean Decade, the Intergovernmental Oceanographic Commission (IOC) of the United Nations Educational, Scientific, and Cultural Organisation (UNESCO), in cooperation with Member States and the global ocean community, prepared an Implementation Plan for the Ocean Decade.

The Ocean Decade defines 'ocean science' in the broadest sense and includes not only the natural and physical sciences but also social sciences, humanities, policy, technology and innovation, and Indigenous, local, and experiential knowledge.

Canada is a proud supporter of the Ocean Decade and members from across the Canadian ocean community have been engaging in various activities since the beginning of the Preparatory Phase (2018-2020), including global and domestic engagement and planning meetings, as well as regional and thematic workshops. In addition, Canada, represented by the Minister of Fisheries, Oceans and the Canadian Coast Guard, is a member of the Ocean Decade Alliance, a network of partners that aims to catalyse support for the Decade.

In follow-up to Canada's Launch Event for the Ocean Decade held in March 2021, Fisheries and Oceans Canada (DFO), the Hakai Institute, and the Quadra Centre for Coastal Dialogue co-hosted a virtual workshop on May 12-13, 2021 to further engage the Canadian ocean community in discussions to inform Canada's Blueprint for the Ocean Decade. Approximately 330 participants provided their input on potential priorities and actions within the context of the seven Ocean Decade Outcomes and considering various cross-cutting themes that were confirmed at the Launch Event (i.e. diversity, equity, and inclusion, co-

designed and co-delivered ocean science, capacity building and exchange, information, data, and knowledge, and communication and awareness-raising). In addition, participants discussed the unique strengths and experiences of the Canadian ocean community to identify where Canada might contribute leadership in advancing the work of the Ocean Decade. Participants identified the following as areas where Canada can demonstrate leadership:

- Embracing and demonstrating effective ways to engage with Indigenous communities through participation of local and Indigenous communities in the co-development and co-design of long-term projects;

- Meaningfully involvement of youth and Early Career Ocean Professionals (ECOPs);

- Advancing gender equity in ocean science;

- Championing ocean literacy domestically and internationally; and

- Engaging in international collaborations to share Canadian knowledge, expertise, and technology, while also advancing emerging domestic ocean industries.

This report does not represent the perspectives of any individual participating organizations, including DFO, but rather presents an overview of the workshop discussions and highlights priority topics and themes to inform the development of Canada's Blueprint for the Ocean Decade. Although the report aims to reflect the ideas put forward by the participants of the workshop, the broad scope of the Ocean Decade means the group may not have discussed some important topics and/or research priorities that may prove relevant to Canada's contribution to the Decade. A successful Ocean Decade will require a continued effort to ensure the ocean science community works together to unlock opportunities and foster an inclusive, collaborative, and innovative transformation in ocean science.

CONTEXT

The 72nd Session of United Nations (UN) General Assembly proclaimed that 2021-2030 would be the UN Decade of Ocean Science for Sustainable Development 2021-2030 (referred to as 'the Ocean Decade'). The Ocean Decade is a global effort that aims to transform ocean science to reverse the decline in ocean health and ensure a sustainable ocean for future generations. In preparation for the Ocean Decade, the Intergovernmental Oceanographic Commission (IOC) of the United Nations Educational, Scientific, and Cultural Organisation (UNESCO), in cooperation with Member States and the global ocean community, prepared an Implementation Plan for the Ocean Decade. This Plan provides a framework for global action and includes details regarding the seven Ocean Decade Outcomes.

The Ocean Decade defines 'ocean science' in the broadest sense and includes not only the natural and physical sciences but also social sciences, humanities, policy, technology and innovation, and Indigenous, local, and experiential knowledge.

The Ocean Decade provides a platform to stimulate ocean science that will increase our understanding of the ocean as well as inform policy and decision-making, facilitating a transition to 'the science we need for the ocean we want'. The Ocean Decade aims to mobilize resources and technological innovation to build capacity, develop scientific knowledge, develop and share infrastructure, and foster partnerships for a sustainable and healthy ocean. Co-design, engagement, and partnerships will be key to the success of the Ocean Decade and a wide range of partners must collectively align their research, investments, and initiatives around a set of common challenges, thus ensuring an exponentially greater result of the collective effort than the sum of the parts.

DECADE OUTCOMES

"THE OCEAN WE WANT"

- A clean ocean
- A healthy & resilient ocean
- A productive ocean
- A predicted ocean
- A safe ocean
- An accessible ocean
- An inspiring & engaging ocean
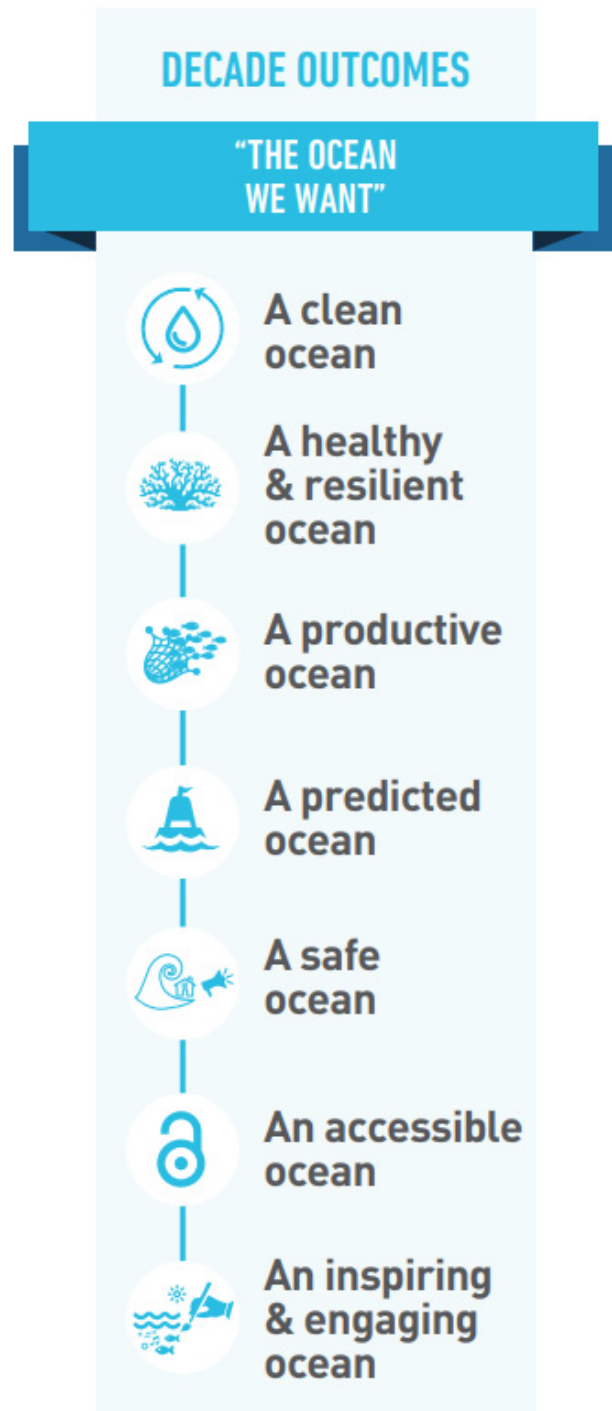
CANADIAN OCEAN DECADE WORKSHOP OVERVIEW

Canada is a proud supporter of the Ocean Decade and members from across the Canadian ocean community have been engaging in various events and initiatives since the beginning of the Preparatory Phase (2018-2020), including global and domestic engagement and planning meetings as well as regional and thematic workshops. In addition, Canada, represented by the Minister of Fisheries, Oceans and the Canadian Coast Guard, is a member of the Ocean Decade Alliance, a network of partners that aim to catalyse support for the Decade.
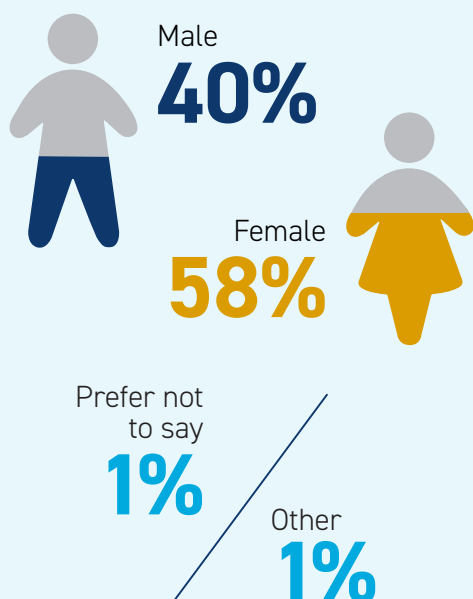
On March 3, 2021, Canada (led by Fisheries and Oceans Canada (DFO)) hosted a Launch Event for the Ocean Decade to inform and generate interest among the Canadian ocean community about this global initiative. An outcome of this event was a commitment by DFO to host a follow-up workshop that would build on the Launch Event and help inform the design of a Canadian Blueprint to advance progress towards Ocean Decade objectives.

The Canadian Ocean Decade Workshop was held virtually on May 12-13, 2021 and was hosted by DFO, the Hakai Institute, and the Quadra Centre for Coastal Dialogue to further engage the Canadian ocean community in discussions to inform Canada's Blueprint for the Ocean Decade. Approximately 330 participants from across the Canadian ocean community attended the workshop and provided their input on potential Canadian priorities and actions within the context of the Ocean Decade.
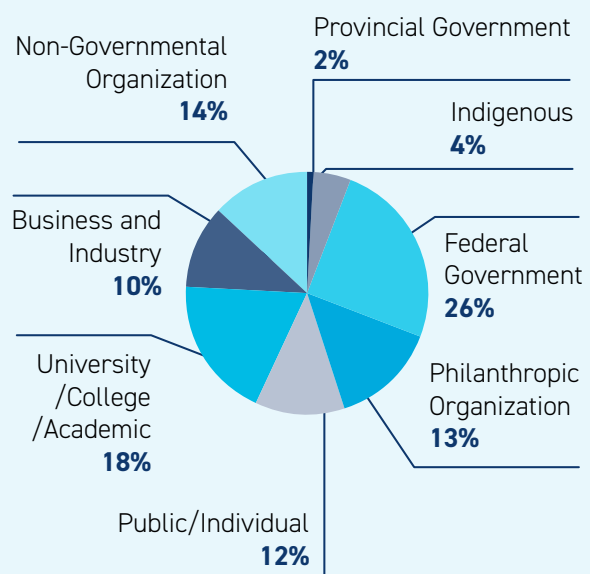
This report presents an overview of the workshop discussions and will inform the development of a Canadian Blueprint for the Ocean Decade as well as highlight areas for action among the Canadian ocean community.

The workshop was moderated by Allison Webb (former Director, Canadian Ocean Decade Office, DFO) and Paul Snelgrove (University Research Professor, Memorial University of Newfoundland). Erik Blaney (Tla'amin Nation) provided a welcome and opening prayer. Throughout the workshop, Ken

GENDER REPRESENTATION AT THE WORKSHOP

Male
40%

Female
58%

Prefer not to say
1%

Other
1%

DISTRIBUTION OF WORKSHOP PARTICIPATION

Non-Governmental Organization **14%**

Provincial Government **2%**

Indigenous **4%**

Business and Industry **10%**

University /College /Academic **18%**

Federal Government **26%**

Philanthropic Organization **13%**

Public/Individual **12%**

Paul (Wolastoqey Nation in New Brunswick), Eric Oliver (Dalhousie University), and Lily Woodbury (Surfrider Foundation) provided inspiring remarks that highlighted their perspectives about the Ocean Decade and their relationships with the ocean.

Participants were organized into working groups that aligned with the seven Ocean Decade Outcomes. As a starting point for discussion, a background document (Annex 1) was provided to each working group that summarized priorities and actions identified for each Outcome at previous Ocean Decade global meetings and regional workshops (i.e. North Atlantic, North Pacific, and Arctic). Led by ocean experts from across Canada, each working group discussed priority areas and supporting actions related to the Ocean Decade Outcomes, cross-cutting themes, and particular topics where Canada might make unique contributions or be well-positioned to demonstrate leadership. Every workshop participant was invited to contribute to two different working groups.

OPPORTUNITIES FOR CANADIAN LEADERSHIP

As part of the discussions in each working group, participants were asked to identify areas where Canada could show leadership, or where the Canadian ocean community might make a unique contribution to the Ocean Decade.

Participants expressed that Canada has an opportunity to **embrace and demonstrate effective ways to engage with Indigenous communities** and to ensure meaningful participation, across the spectrum of actions required for sustainability, from developing ocean science research proposals to co-managing resources and coastal environments. In particular, workshop participants prioritized inclusion of Two-Eyed Seeing[1] as an approach to engaging knowledge systems in our understanding of the ocean.

In addition, participants observed that many communities living in remote areas offers Canada unique opportunities to foster broad **participation of local and Indigenous communities in the co-development and co-design of long-term projects** in those regions. Projects of this kind can be used to acquire robust information and datasets that might not otherwise be possible, particularly for Arctic ecosystems. Notably, some participants expressed that **participatory, community-based approaches to ocean science** (e.g. citizen science initiatives, local environmental observer networks, etc.), are not only effective in supporting remote research but also in many other aspects of ocean science. It was discussed that in some circumstances, sustainable solutions that advance Ocean Decade work will benefit from **engagement of Canada's full suite of rights-holders and ocean stakeholders** (e.g. Indigenous Peoples, coastal communities, industry, government, non-government organizations, academia – both natural and social scientists, etc.).

Participants expressed that Canada, with its access to the ocean and focus on supporting a sustainable blue economy, could position itself **as a leader in emerging ocean industries**. To facilitate this role, it will require developing tools and technologies that increase the accessibility of these industries (e.g. offshore wind and wave, tidal power, aquaculture, autonomous shipping) nationally and internationally. The significant opportunities for international leadership and collaboration in this area could contribute to sustainable development as well as vibrant coastal communities.

Meaningful involvement of youth and Early Career Ocean Professionals (ECOPs) throughout the Ocean Decade was noted as an important leadership opportunity for Canada. Further effort is required to develop specific actions, noting preliminary work in a global context as occurred, including the establishment of a Global ECOPs Programme. Participants also stressed the importance in continuing Canada's efforts to **advance gender equity in ocean science**, including

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[1]   Reid, A. et al. (2021) "Two-Eyed Seeing": An Indigenous framework to transform fisheries research and management. *Fish and Fisheries 22(2)*, 243-261. https://onlinelibrary.wiley.com/doi/full/10.1111/faf.12516

expanding the scope beyond women to consider other genders, as well as other equity groups.

At the time of the workshop, Canada was the only country with a National Ocean Literacy Strategy. It was suggested that Canada could leverage this achievement to **advance ocean literacy domestically and provide leadership on international ocean literacy initiatives**. Increased ocean literacy, with more ocean education, training, and awareness throughout the country, will in turn support long-term workforce and skills development.

Some participants noted that Canada has significant capacity in ocean observation and has initiated the Canadian Integrated Ocean Observing System (CIOOS) and has linkages to the Global Ocean Observing System (GOOS) to ensure visibility of, and improved access to, Canadian data internationally. **International collaborations provide an opportunity to share Canadian knowledge, expertise, and technology**. In addition, Canada is uniquely positioned to compare observations, models and predictions in three different ocean ecosystems within longitudinal and latitudinal gradients and between Atlantic, Pacific and Arctic systems (e.g. upwelling zones and fjords) and in some locations, the ocean-sea ice interface.

CROSS-CUTTING THEMES

Cross-cutting themes were identified through previous Ocean Decade processes, in particular at the North Atlantic Regional Workshop, and five were highlighted as applicable to all aspects of Canadian efforts under the Ocean Decade. The success of the Ocean Decade will depend on weaving these themes into activities designed to address Ocean Decade Outcomes, as well as identifying specific actions to advance progress in these areas. In addition to cutting across various ocean science activities, in many cases these themes are also intricately related to each other.

The five cross-cutting themes suggested to underpin Canadian efforts to support the Ocean Decade are:

- Diversity, equity, and inclusion;

- Co-designed and co-delivered ocean science;

- Capacity building and exchange;

- Information, data, and knowledge; and

- Communication and awareness-raising.

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Diversity, Equity, and Inclusion

To achieve the Ocean Decade objectives, participants highlighted that the ocean community must find a way to engage all segments of Canadian society in efforts towards ensuring a healthy and sustainable ocean. In particular the importance of advancing gender equity featured prominently in the workshop discussions. When embarking on the design of ocean science projects, coordinators should be asking themselves "who is in the room?" and "who is missing?" to ensure the relevance of outcomes of their project to multiple users and recipients of the knowledge and/or information.

Workshop participants emphasized that Indigenous Peoples are not stakeholders and that consultation and meaningful engagement of Indigenous Peoples are essential for ocean science projects. It was recognized that working with Indigenous communities as equal partners and through active and meaningful collaboration, has the opportunity to generate mutual benefits, opportunities, and resources for all parties involved. Further, participants discussed that learning from traditional knowledge and practices provide foundational knowledge for learning to live sustainably with nature.

The importance of involving youth and early career ocean professionals (ECOPs) in the Ocean Decade was a repeating theme in the discussions, with suggestions to provide opportunities for mentorship, networking, training, and intergenerational sharing as important priorities. Workshop participants recommended the coordination of a Canadian ECOPs network to help ensure their inclusion in Ocean Decade activities both domestically and internationally.

Co-designed and Co-delivered Ocean Science

Participants discussed the need to ensure project relevance to Canadians and policymakers and so ocean science projects that address community-driven priorities and that are designed through partnerships that benefit from diverse yet complementary expertise are necessary. Scenario planning that asks "what do we want the future to look like?" is an important first step in developing ocean science projects that align with the spirit of the Ocean Decade.

In addition, feedback from the discussion was that Ocean Decade activities should include community and participatory science more often and value their data contribution and engagement. These kinds of initiatives, like shoreline cleanups and guardian programs, engage and empower communities, provide valuable "boots-on-the-ground" local knowledge, and encourage collaboration and consultation. Sustaining momentum will require an active engagement to develop and communicate the outcomes of citizen science.

Capacity Building and Exchange

Participants noted that ocean science capacity in Canada, and more broadly, will only advance if infrastructure, individuals, and collaborations are supported from a variety of resource perspectives, recognizing that some suggestions may have substantial financial implications. Priority infrastructure considerations brought forward in the discussions included cost-effective sampling

and analysis methods, digital infrastructure, low-cost and widely-available technologies, access to research vessels, and remote sensing capacity. Opportunities for individuals to learn, be mentored, and reskilled, where necessary, will lead to ocean science jobs with fair wages and a healthy workplace culture. Collaborations should further expand existing partnerships, support community initiatives, and include partners from multiple sectors.

Information, Data, and Knowledge

It was noted that incorporating various knowledge systems in the Ocean Decade will require trust between groups, especially with regard to protocols for ethical sharing and stewardship of sensitive data.

With many types of data and a massive geographical scope, there is a need to promote data collection standards to facilitate the sharing and archiving of data for multiple purposes. Ensuring accessibility of data through transparency, data democratization, and liberation of archives, as well as suitable data infrastructure will also be critical.

Communication and Awareness-Raising

It was suggested that the intended audiences must be identified at the onset of every ocean science initiative to effectively communicate the science and engage in meaningful outreach activities. Participants noted that communication of results in various formats is an essential component to achieving broad dissemination of information and improved understanding of the ocean, particularly by civil society and policymakers. It was recognized that to achieve this objective will require creativity in communication approaches, including innovative uses of storytelling, mass media in various formats, and the arts.

It was suggested that Canada should leverage the distinctive skill sets and strengths of the ocean science community to produce more effective, targeted content, especially when building an ocean curriculum and advancing ocean literacy. Communication efforts should aim to inspire others by showcasing not only stories of success but also failure and what we've learned from those experiences.

POTENTIAL PRIORITIES AND ACTIONS BY OCEAN DECADE OUTCOME

Working groups identified priorities and actions related to their specific Ocean Decade Outcome through verbal discussions, online mural boards, and/or live polls. The summary below reflects the ideas generated within the seven working groups in an integrated narrative that also considers the background information prepared for the workshop (Annex 1).

Although the priorities and actions included in this report provide a starting point for the Canadian ocean community to make progress towards supporting Ocean Decade objectives, many additional meaningful ocean science activities will also contribute to this broader initiative.

Outcome 1: A Clean Ocean whereby sources of pollution are identified, quantified, and reduced and pollutants are removed.

An increased understanding of the spatial and temporal distribution of pollutants, as well as their pathways of effects, was identified as a priority by participants. Priority pollutants include CO_2, chemicals and nutrients, plastics, invasive species, underwater noise, and emerging pollutants and contaminants such as light and pharmaceuticals.

Furthermore, the cumulative effects of multiple pollutants need to be assessed to understand better the interactions between different stressors, particularly in a changing climate. Mapping the distribution of legacy contaminants and identifying/detecting emerging pollutants in coastal environments using standardized, coordinated methods are important steps for effective mitigation.

The impact of noise and light pollution on marine life and ecosystems needs to be understood to effectively manage these stressors. Participants emphasized the need to prioritize generating the science needed to help address noise from shipping and seismic exploration, and light pollution caused by coastal industries.

Society needs solutions-based management approaches and tools to inform remediation, waste management, dispersal, and use as well as to motivate societal and political change. In addition, workshop participants recognized the utility of identifying thresholds and standard assessment methods to quantify the risks and benefits as well as evaluating the trade-offs between different management actions.

In addition, participants discussed the need to advance innovative solutions to remove invasive species and pollutants from ship wash water, bilge water, sewage, and ballast water discharges, as well as biofouling could help reduce pollutant

inputs into the ocean and the spread of invasive species. Furthermore, the ocean community would welcome ocean science solutions to inform programs and policies to support a circular economy.

It was noted that advancing a coordinated approach and sharing of data, information, and expertise among diverse users and contributors/sources will require shared data and information platforms and facilities, as well as cost-effective methods for sampling and analysis (including the use of sensors and the deployment of autonomous observing platforms to supplement ship-based activities)

Outcome 2: A Healthy and Resilient Ocean where marine ecosystems are understood, protected, restored, and managed.

The workshop discussion related to Outcome #2 consistently emphasized the need for an increased understanding of ecosystem structure and function, as well as ocean structure and function. In particular, the discussion highlighted the inter-dependency between natural systems and how to evaluate ecosystem resilience, tipping points, and

adaptive capacity. The group also noted interest in land-ocean and ocean-atmosphere interfaces in the context of climate change.

Participants indicated a need for modelling that can predict ecosystem changes and phase shifts, as well as the potential impacts of unknown and/or cumulative stressors requires improved understanding of major driving factors and trends of marine ecosystems. In addition, systematic methods for evaluating and mapping the impacts of cumulative stressors (including ocean acidification, deoxygenation, marine heatwaves) should be considered, as well as identifying indicators for a healthy and resilient ocean.

Participants agreed that standardized protocols for assessing marine ecosystem health, as well as the development of new technologies (e.g. sensors) and establishment of protocols would progress network objectives, as would the global coordination of biological observation networks. Progress in achieving this Outcome demands long-term data and monitoring initiatives, that result in open and accessible data.

Workshop participants expressed strong interest in studies to evaluate the effectiveness and connectivity of ecosystem structure within and across marine protected areas, as well as socio-ecological trade-off analyses to predict costs and benefits of decisions. The valuation of marine ecosystem services will contribute to sustainable resource use, as will the effective implementation of ecosystem-based management frameworks and/or marine spatial planning initiatives.

Outcome 3: A Productive Ocean supporting a sustainable food supply and ocean economy.

The participants of this working group were particularly interested in sustainable fisheries and sustainable aquaculture (a productive ocean) as well as climate change and pollution (a sustainable ocean). Two broad themes that ran through the discussions were: 1) the need for a partnership approach to management and governance; and 2) acknowledgement of the underlying 'human dimension' of the issues related to achieving a sustainable Productive Ocean.

Elaborating on these broad themes, participants indicated that a future Productive Ocean will differ from the past ocean; climate change, pollution, and human harvesting pressures make it impossible to revert to a pristine ocean untouched by anthropogenic impacts. Achieving a broad consensus on what a sustainable productive ocean looks like, including what sustainable aquaculture and fisheries entail, offers a major challenge.

Participants highlighted the need to improve fisheries science, particularly for data-limited species and species of importance to Indigenous communities, through the identification of ecosystem thresholds and sustainability indicators to support inclusive, integrated ecosystem assessments and ecosystem-based management approaches, as well as the future of food production (particularly for Indigenous communities and subsistence fisheries). Furthermore, participants agreed that we must enhance our understanding of ecosystem structure and function, including models to advance understanding of species interactions and food webs, as well as population dynamics of target fisheries and keystone species.

In addition, it was noted that we must improve our understanding of climate change impacts on fishery production, distribution, community structure, and catch through improved observations and data dissemination, development of coupled physical-biological modelling, and studies on the effects of ocean acidification and deoxygenation.

Participants discussed the need for researchers to define the chemical and biological impacts of aquaculture and to improve regional and biogeochemical modelling to assist aquaculture siting, while managers must establish guidelines for waste treatment, chemical substances, genetically modified organisms (GMO) and endemic species, monitoring and evaluation, and food safety. It was highlighted in the discussions that the Canadian ocean community must advance innovation to support sustainable fisheries and aquaculture, and the development of technologies to support renewable energy (e.g. wind, waves, tidal) and marine resource extraction (e.g. biotechnology/genetics, minerals and deep-sea mining).

Participants also reflected on the importance of improving our understanding of social structures (e.g. justice and equity issues, people/resource

relationships, social vulnerabilities) to enhance resilience of coastal communities and reduce vulnerabilities. This will be possible only if Ocean Decade proponents identify emerging ocean issues that are or may affect human physical and psychological health, and map and present Indigenous and local knowledge to understand past, present, and future ecosystem services and dynamics.

In addition, participants indicated that we must aim to determine the effectiveness of area-based management and to understand trade-offs between different uses of the ocean and its resources to inform spatial planning and integrated ecosystem management. Included in these discussions was the need for society to better understand of the role that Marine Protected Areas and other conservation measures will play, to enact measures that achieve the desired outcomes, while also accommodating marine industry, coastal livelihoods, and culture. Finally, understanding our progress toward a Productive Ocean will require better indicators of ecosystem and community health that can inform policy and practice for long-term sustainability.

Outcome 4: A Predicted Ocean where society understands and can respond to changing ocean conditions.

The working group reiterated *"Predicting what, for whom?"* as a key message, along with the development of observations and model goals, in collaboration with the end user as a critical step in planning for a predicted ocean. Participants agreed that priority should be given to projects that directly benefit society and that have a practical application to secure sustained ocean observing program investments (e.g. weather modelling and forecasting).

Through these discussions, participants noted that the measurement of oceanographic parameters (considering current and future activities data sources) should be prioritized under this Outcome, and that terminology should be modified so that a 'predicted ocean' also includes biological and ecological components and considerations. It is also important to identify relevant and achievable seasonal, spatial and physical scales, with an over-arching priority of an inclusive multi-disciplinary approach.

Participants discussed that a Predicted Ocean should embrace accessible science through enhancing science communication and data sharing and that this objective requires a balanced emphasis in observation collection, modeling, and communication of information in a form that stakeholders need and understand for their purpose.

Key concepts in action planning that were highlighted by participants include a coordinated approach to build and/or expand networks for ocean observation and modeling, with the first steps related to contacting and organizing current capacity, then expanding following the identification of gaps. Workshop participants highlighted that several networks were highlighted for their successful collaboration and/or organizational efforts, including the Canadian Integrated Ocean Observing System (CIOOS), the Global Ocean Observing System (GOOS), Integrated Marine Observing System (IMOS), National Collaborative

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Research Infrastructure Strategy (NCRIS), Marine Biodiversity Observing Network (MBON), and Marine Environmental Observation Prediction and Response Network (MEOPAR) Community of Practice on Ocean Prediction. The examples provided are not comprehensive and Decade participants should make every effort to reach out to other relevant organizations; the group proposed the creation of a Task Team to lead this effort.

The critical need for open-source data emphasized by the working group also points to the essential need for a centralized database for all oceanic and environmental data. In addition, data management systems should be improved so that data is accurate, updated, and appropriate for intended users. This effort could include development of a standardized framework for ocean observations to facilitate data sharing and integration similar to that in development by GOOS. Participants also noted the importance of establishing SMART (specific, measurable, audience-specific, realistic, and time-bound) objectives for baseline parameters and indicators to monitor and model changes and predict trends as outputs for determining environmental change, stressors and anthropogenic impacts (e.g. climate change, sea ice change, ocean acidification, coastal development and harmful algae blooms).

Outcome 5: A Safe Ocean where life and livelihoods are protected from ocean-related hazards.

When considering priorities for a safe ocean, participants raised areas of concern grouped into three thematic areas: marine ecosystems, communities, and ship-related activities. Participants recognized safe and healthy marine ecosystems as instrumental for human safety because human health and access to healthy food supplies depends on marine ecosystems relatively free from both human pollutants and biotoxins. Some participants wondered whether, in this context, Canada's Ocean Decade effort might extend to consider a safe ocean beyond human safety to include the safety of ecosystems.

Participants indicated that ensuring the safety of coastal communities could consider numerous

dimensions, including monitoring, prediction and risk mitigation for natural hazards such as tsunamis, storm surge, and ice movement; sea level rise will continue to exacerbate these natural hazards. This concern ties into some aspects of development and emergency response planning, which sometimes fail to account for long-term sea level change. Participants agreed that physical safety affordances, such as building upgrades, vertical evacuation towers and other physical improvements to mitigate risk of tsunamis, storm surges, earthquakes and coastal erosion add to these planning concerns.

To support safer coastal communities, participants recognized the crucial need for improved real-time sea state conditions and forecast products. But improved forecasting and alerting will not benefit remote locations and vessels at sea that lack adequate connectivity, therefore emphasizing the need to enhance communications infrastructure and protocols. Participants highlighted the need for low-cost systems that can provide timely information as well as fill coverage gaps for VHF radio-based systems.

Participants identified shipping and maritime operations as another key focal area. Improving safety in this domain will require improved traffic mapping, routing and monitoring, and mapping of derelict vessels. Emergency response systems should also be enhanced to improve search and rescue and oil spill response operations.

Discussion in this working group was particularly focused on the importance of trust to activate safety measures, given that trust represents the essential component to making all actions "implementable". It was emphasized that building trust is neither quick nor simple, it takes time, and it requires that government and other policy and decision-makers listen, include Indigenous Peoples and ocean stakeholders, and show genuine transparency.

Participants identified five different types of activities that will help build trust:

1. Collaboration speaks to the importance of including Indigenous communities, all levels of government, scientists and academics, and users across various ocean sectors. These groups all bring something to the table, an aspect that must be recognized and welcomed.

2. Communication should go beyond words to making relevant data available, accessible, intelligible, and actionable. Data must be transformed into intelligence to support informed decision-making by all members of the ocean community not just those with data expertise.

3. The data products generated should support real needs in local communities. Examples include real time sea and ice state for local navigation, coastal land use planning maps, or tsunami and storm flood warning products.

4. Long-term impacts can be made in regulations, in issues such as ship traffic, derelict vessel management, coastal zoning and simplified fisheries harvest parameters. For example, regulating the shipping industry could reduce and potentially even eliminate greenhouse gas emissions, which contribute to sea level rise and other climate and weather-related disasters that threaten coastal communities.

5. Government support was highlighted as instrumental for achieving a safer ocean. Indigenous communities and local/provincial governments could greatly benefit from partnerships that would support government-funded staffing of students and co-ops to work embedded in local organizations on capacity building, monitoring and research projects.

Outcome 6: An Accessible Ocean with open and equitable access to data, information, technology, and innovation.

The working group for an accessible ocean strongly encouraged a desire for Canada to set an example by fostering strong Indigenous leadership while addressing challenges of engagement with remote communities (i.e. technology, digital literacy challenges).

This group noted that inclusivity would require not only a willingness, but also ensuring that we enable participation by all. This objective could be facilitated by creating and maintaining
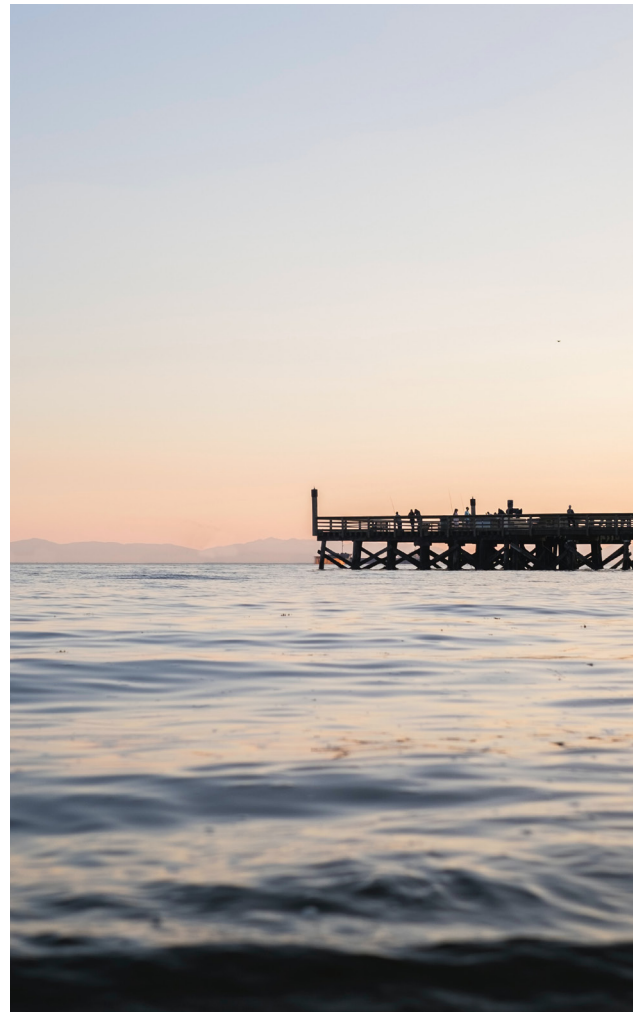
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an open, standardized data-sharing platform that covers all domains and knowledge systems (e.g. environmental, social, and economic data, Indigenous and local knowledge). Such an effort should incorporate FAIR (Findable, Accessible, Interoperable and Reusable) and CARE (Collective benefit, Authority to control, Responsibility and Ethics) principles, emphasizing interoperability and wide accessibility.

In addition, this Outcome requires developing and implementing mechanisms to improve sharing of, and access to, physical infrastructure. Participants also recognized the importance of programs to increase skills and to provide opportunities to engage in data collection, knowledge generation, and technology development.

The goals of accessible data and improved digital literacy and connectivity are not unique to the Ocean Decade, however the Decade emphasizes a clear desire and need to do more in terms of capacity building, as well as communicating and leveraging success. Participants also noted a need to improve understanding of 'open data' and 'open by default', noting widespread misconceptions

that these concepts intend to override data sovereignty. Participants also suggested that projects conducted under the Ocean Decade should pay specific attention to the desire for open and accessible data, with suggestions to enforce this need (where eligible – note existing approaches to assess eligibility for release) as a condition of funding.

Participants also proposed enhancement of the collection and management of data, including the use of real time, high resolution data collected using international standards (and to develop standards where they do not already exist). It was also noted that an important initiative within this theme would be the development of metadata/data standards for emerging data types such as environmental DNA (eDNA), machine learning/artificial intelligence outputs, model output, marine plastics, ocean sound, etc.

The group emphasized the desirability of improved ocean observations and monitoring that aim to provide products relevant and accessible to inform management, innovation, and decision-making, prioritizing a cohesive Canadian approach to ocean observation with defined goals and increased observation and monitoring efforts in the Arctic is a priority.

Outcome 7: An Inspiring and Engaging Ocean where society understands and values the ocean in relation to human wellbeing and sustainable development.

Participants in this working group highlighted that the identification of effective ways to mobilize knowledge systems (particularly Indigenous and local knowledge), share scientific outcomes and important messages, increase public awareness of the importance of ocean science, and increase the uptake of science in policy and decision-making will be crucial in the Ocean Decade.

It was agreed that success of the Ocean Decade will depend on effective and active engagement of Canadians, through creative communication strategies and methods including the use of storytelling, arts, and social and mainstream media (i.e. "show people, don't tell people"). Similarly,

the group noted a need to develop innovative and creative approaches to communicate scientific information, data, and knowledge, in particular for messages aimed at a diversity of groups. It was noted that a successful outcome crucially depends on the engagement of different voices in these efforts, including those of women, youth, Indigenous Peoples, and other equity groups.

Participants discussed that actions to support the removal of systemic barriers that are preventing inclusive and equitable participation in ocean science must be identified, including specific initiatives to promote and advance gender equity in ocean science and inspire, empower, and support the next generation of ocean leaders. Further, opportunities such as leadership and ambassador programs, as well as exchanges (e.g. Indigenous and non-Indigenous, coastal and inland, etc.) offer an effective way to advance this goal, particularly for youth. It is essential to make connections between ocean and freshwater systems, and between humans and those systems. To this end, participants agreed that opportunities for in-person, hands-on experiences with aquatic environments should be prioritized, including the creation of more "blue spaces" to connect society with the ocean, particularly groups that experience systemic barriers to doing so, are a useful tool (e.g. coastal parks, areas dedicated to swimming, fishing, paddling, etc.).

In addition, the group noted that ensuring messages and methods resonate with the intended audience requires inclusion of social sciences in understanding what inspires and engages Canadians, and requires funding at various levels from micro-grants for grassroots projects to larger-scale ocean literacy initiatives.

Participants agreed that educational resources appropriate for a wide range of audiences must be developed, including the integration of ocean literacy into formal and informal education approaches. Priority resources include a database of Canadian ocean literacy resources and a campaign to communicate with formal educators to ensure availability of ocean curricula in classrooms.

This working group emphasized that a key step to addressing this Outcome will be to advance the implementation of Canada's national ocean literacy strategy to better coordinate national efforts, including identifying metrics to track benefits and impacts.

CONCLUSIONS

The broad scope of the work envisaged during the Ocean Decade demands a collaborative approach with an emphasis on inclusion, co-design, partnerships, and transdisciplinarity. To achieve the objectives of the Ocean Decade will require the Canadian ocean science community to rally together to create a collective effort exponentially greater than the sum of individual contributions.

This report provides an overview of potential Canadian priorities and actions suggested by workshop participants within the context of the seven Ocean Decade Outcomes and also considers several important cross-cutting themes. In addition, this report provides examples of unique strengths and experiences of the Canadian ocean community which underpin initial areas where participants suggested Canada can show leadership in the Ocean Decade. Figure 1 provides a visual representation of the workshop discussions.

The contents of this report are intended to provide the Canadian ocean science community with a starting point to advance Ocean Decade objectives. Although the report aims to reflect ideas put forward by participants in the workshop, the broad scope of the Ocean Decade means that the discussions may not have included some important topics and/or research priorities that are nonetheless still relevant to Canada's contribution to the Decade. A truly successful Ocean Decade will require a continued effort to ensure the ocean science community works together to unlock opportunities and foster a transformation in ocean science that is inclusive, collaborative, and innovative.

The Canadian Blueprint currently under development will help guide Canada's support for the Ocean Decade. This summary report, along with other sources of information and inspiration, will inform that Blueprint.
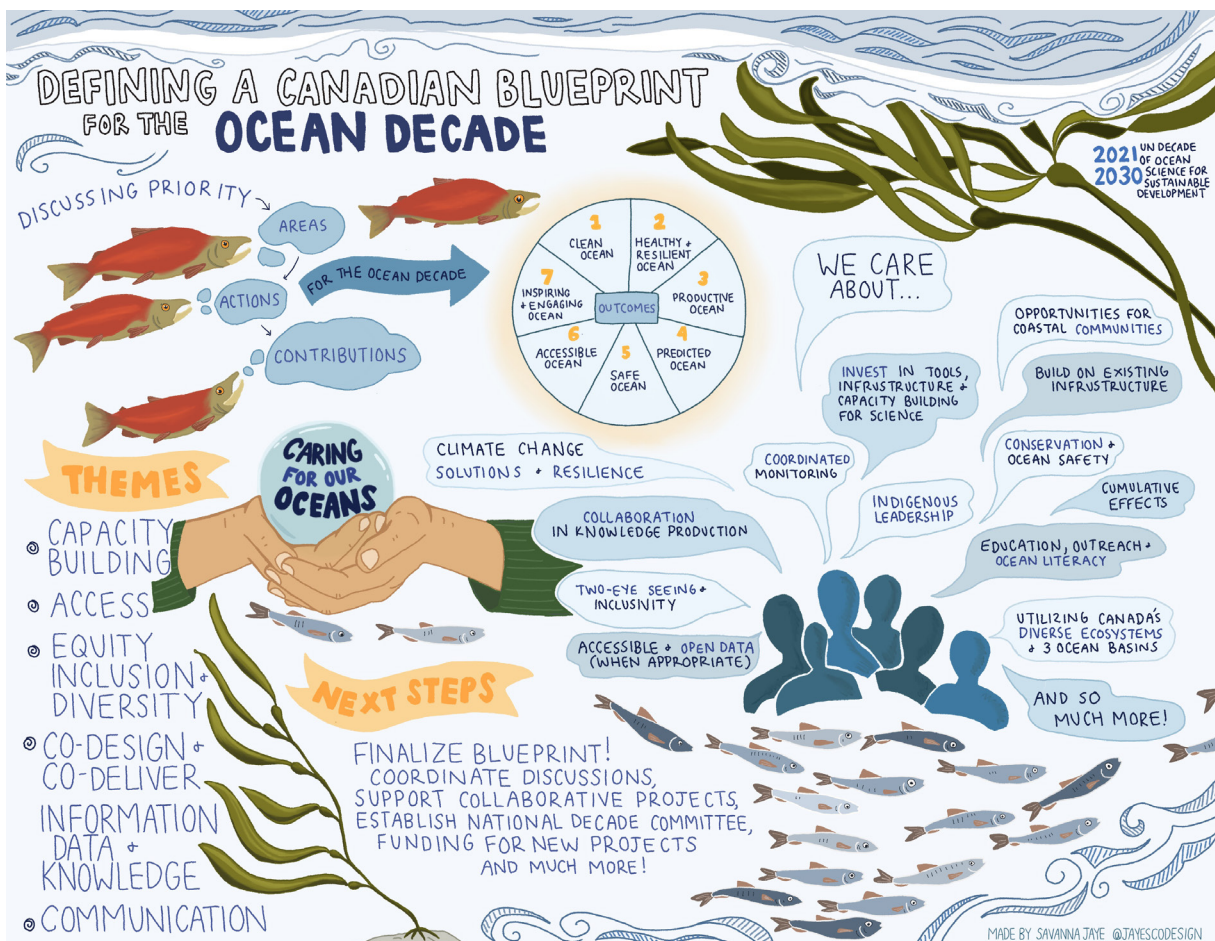
FIGURE 1. A visual representation of the Canadian Ocean Decade workshop discussion (May 12-13, 2021).

ANNEX 1. OVERVIEW OF OCEAN SCIENCE PRIORITIES FROM REGIONAL WORKSHOPS OF RELEVANCE TO CANADA

	North Atlantic Workshop	North Pacific Workshop	Arctic Action Plan
Outcome #1 – A Clean Ocean	• Increase solutions-focused knowledge on CO_2, chemical and nutrient pollutants, plastics, invasive species, noise, and emerging pollutants and contaminants such as light and pharmaceutical pollution. • Develop risk thresholds and risk assessment methods for understanding impacts on biota and human health under climate change and multiple stressors, including tools and metrics. • Develop tools to quantify risks and benefits and evaluate trade-offs for different management actions to manage the effects of pollution.	• Better understand the spatial and temporal distribution of pollutants using standardized monitoring and modelling. • Develop guidelines specific to pollutants to eliminate, reduce, or mitigate effects of pollutants on species, ecosystems, and humans. • Improve science-based management and tools for remediation, waste management, and dispersal and use.	• Understand consequences of remobilization of contaminants and synergistic and cumulative effects of multiple contaminants. • Understand the distribution and effects of micro- and macroplastics. • Understand anthropogenic underwater noise. • Understand the combined effects of climate change and other anthropogenic stressors, along with the spreading of pollutants.

	North Atlantic Workshop	North Pacific Workshop	Arctic Action Plan
Outcome #2 – A Healthy and Resilient Ocean	• Evaluate ecosystem resilience to ecological regime shifts; improve projections of site-specific costs and benefits of climate change adaptation. • Understand ocean structure and function, including global marine processes. • Quantify socio-ecological trade-offs of human activities. • Identify what types of transformative governance is required to assimilate info into policy and decision-making.	• Understand mesopelagic (and other realms) ecosystem structure and function. • Interlinkages between ocean-land, ocean-atmosphere, and surface ocean-deep ocean, including carbon cycling, oxygen flux, nitrogen runoff, ocean circulation, deep sea ecosystems, waste streams. • Impact of cumulative stressors on the ocean (systemic methods for evaluation) including ocean acidification, deoxygenation, heat, indicators for adaptive capacity. • Standardization of essential ocean variables and sampling issues for data comparison. • Long-term knowledge and monitoring	• Understand diverse Arctic ecosystems given the significant differences between ecosystem types and across geographies. • Establish baselines to understand ecosystem resilience and adaptive capacity. • Increase knowledge of land-ocean interactions, including measures to mitigate impact of freshwater fluxes and coastal erosion. • Research and monitoring of seabed and subsurface and mapping of ocean floor.

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	North Atlantic Workshop	North Pacific Workshop	Arctic Action Plan
Outcome #3 – A Productive Ocean	• Research and monitoring to support inclusive integrated ecosystem assessments and ecosystem-based management approaches. • Determining the effectiveness of area-based management in the context of harvesting. • Innovations to reduce fisheries impacts on ecosystems. • Development of technologies to support marine renewable resources and other ocean sectors. • Development of innovative sustainable aquaculture methods.	• Improve fish stock assessments (focusing on data-limited species), including identification of ecosystem thresholds and sustainability indicators. • Support for ecologically-friendly aquaculture. • Increase understanding of climate change impacts on fishery production, community structure, catch, and human societies. • Improved understanding of ecosystem structure and function, particularly trophic-linkages and impacts of climate variability and change. • Efforts to help understand the future of food production. • Understanding social structures to enhance resilience of coastal communities and reduce vulnerabilities. • Understand trade-offs between different ocean uses and its resources.	• Seabed and habitat mapping, assessment of species distributions and migrations with the aim of understanding connectivity to support ecosystem assessments and shared management demands. • Map and present Indigenous and local knowledge to understand present and future value of ecosystem services; inclusion of Indigenous knowledge in policy and decision-making. • Trade-off analyses between sectors to inform spatial planning and integrated ecosystem management, including consideration of successes and failures to date. • Increased understanding of fish stocks and population dynamics, including impacts of changes on subsistence fisheries and Indigenous communities. • Impacts of contaminants on human health, with a focus on Indigenous subsistence fisheries.

	North Atlantic Workshop	North Pacific Workshop	Arctic Action Plan
Outcome #4 – A Predicted Ocean	• Observe and characterize the state of the ocean, its use, and human interactions to initialize models as the basis for mechanistic understanding. • Understand ocean processes to improve prediction models, including risk assessment and uncertainty analysis. • Predict ocean conditions in order to provide info to users about future conditions, based on adequate models that are underpinned by adequate observations. • Provide data and information to those that need it, when they need it through dedicated initiatives or programs.	• Four focus areas identified: 1) Role of ocean in climate prediction; 2) Ocean predictions; 3) Ecosystem predictions; and 4) Marine hazards. • Predictions of sea ice loss. • Improved biogeochemical forecast and data assimilation capabilities for important fishing areas (e.g. coastal areas, upwelling areas, etc.). • Improve understanding of atmosphere-ocean interactions, ocean circulation and mixing, and temperature forecasts. • Develop novel ocean models and climate coupled models (ocean-atmosphere-land-ice). • Better resolve representation of nutrient inputs and discharge from rivers. • Develop ocean acidification forecasting capabilities to assess multi-stressor impacts on marine ecosystem components. • Improve observing systems and ability to analyze big data through technology development.	• Understand the ocean-climate nexus, including climatic, biogeochemical, and ecological tipping points. • Design purpose-built tools to predict impacts of sea-ice loss, sea level rise, ocean circulation, and storm tracks to support climate adaptation. • Implement a sustained observation program that collects data on atmospheric, geophysical, glacial, biogeochemical, and ecological parameters, as well as information on social and economic activities and anthropogenic stressors. • Establish baseline status and trends, including sea ice, weather conditions and sea state, ocean and coastal circulation, ecosystem structure and dynamics, carbon fluxes, anthropogenic pressures, contaminants, species distribution.

	North Atlantic Workshop	North Pacific Workshop	Arctic Action Plan
Outcome #5 – A Safe Ocean	• Increase basin-wide, multi-scale understanding of hazard vulnerabilities, sources of resilience, and previous and potential impacts. • Increase knowledge of sea level rise, including storm-related impacts (offshore and inland) including on infrastructure. • Better understanding of risks associated with increased and changing ocean traffic. • Address sectoral and regional gaps in identifying and managing ocean-related risk, including through training opportunities. • Address gaps in research and monitoring of public and occupational health effects of *Saragassum*, algae blooms, shellfish toxins. • Generate a risk map that includes coastal and offshore areas and that underpins a framework for action as well as the design of a multi-hazard warning system.	• Discussion focused on tsunamis, marine heat waves, typhoon/high wave storm surge, and harmful algal blooms. • Develop frequency and magnitude models of hazards, identify susceptible areas, conduct risk assessment and appropriate risk management. • Develop monitoring, prediction, and warning systems for priority hazards. • Develop and deploy technologies to improve prediction capabilities. • Integrate local and traditional knowledge into protocols and plans; increase co-design in research programs/ identification of priorities. • Improve understanding of species identification and distribution for Harmful Algal Blooms. • Improve predictions re: climate change impacts, including the impacts of ocean acidification on ecosystems and food security.	• Identify and assess human health or safety risks, both individually and cumulatively, to disasters. • Develop purpose-built tools to enable sea-ice charting and forecasting, and anthropogenic stressors on human health. • Develop information services for safe navigation, including integration of Indigenous and local knowledge into products such as navigational charts, ice charts, etc. • Provide accurate forecasting of ice, ocean, and sea state variables to inform Search and Rescue and Oil Spill Response. • Collate, translate, merge, and distribute data and hazard mapping to local communities.

	North Atlantic Workshop	North Pacific Workshop	Arctic Action Plan
Outcome #6 – An Accessible Ocean	• Build and support a digital twin ocean that includes rapid, standardized, and credited data and information sharing. • Define goals for a North Atlantic ocean observing system. • Identify best practices (in particular FAIR[2] and CARE[3] principles), shared facilities, and capacity exchange opportunities, including standards for data of all types to facilitate and optimize sharing and accessibility across systems and projects. • Consider different knowledge systems and implement appropriate data principles. • Ensure consistent access to data and interoperability, as well as improved coordination and interoperation between systems/platforms. • Ensure co-designed/ interdisciplinary projects that integrate different knowledge systems.	• The growing data volume is a barrier to information transfer – need to improve access to *relevant* ocean data. • Standardized ocean health monitoring and reporting. • Determine how to best integrate data/ information and convert it into useful data products; build capacity for data processing, analysis, and management. • Improve ocean observations and monitoring in developing countries, least developed countries and small island developing States, key regions, and on the high-seas.	• Share physical and digital infrastructure, interoperable/ standardized data, and support human capacity building and exchange. • Create and maintain an open data-sharing platform that covers all domains (e.g. environmental, social, and economic data) and incorporates FAIR and CARE principles. • Development of new generation of fit-for-purpose technologies that can withstand harsh Arctic conditions and can be operated to an increasingly remote degree.

[2]   FAIR - Findable, Accessible, Interoperable and Reusable principles
[3]   CARE - Collective benefit, Authority to control, Responsibility and Ethics principles

	North Atlantic Workshop	North Pacific Workshop	Arctic Action Plan
Outcome #7 – An Inspiring and Engaging Ocean	• Ocean literacy research program that includes measuring and monitoring of baselines and impacts of effort. • Integrate ocean literacy/science communication experts into research projects. • Improve understanding of the socio-economic values of the ocean, including relevant products and services. • Support citizen participation models for monitoring and ensure transfer of knowledge/scientific results to local communities. • Develop mechanisms to highlight the contribution of Indigenous and local knowledge in ocean science. • Improve coordination among ocean literacy activities and advance the integration of ocean knowledge and learning in school curricula.	• Widen and strengthen citizen science. • Develop communication mechanisms, including educational modules. • Develop methods to characterize and incorporate Indigenous and local knowledge systems. • Change the narrative of ocean science from simply identifying problems, but to supporting solution design. • Integrate science and art/culture, including through partnerships with museums and aquaria.	• Embrace Indigenous and local knowledge. • Initiate citizen science activities to collect alternative sources of information and raise engagement among local and Indigenous communities. • Increase knowledge on human behaviour and reaction to environmental changes. • Integrate cultural, historical, and social values into models, projections, and decisions.