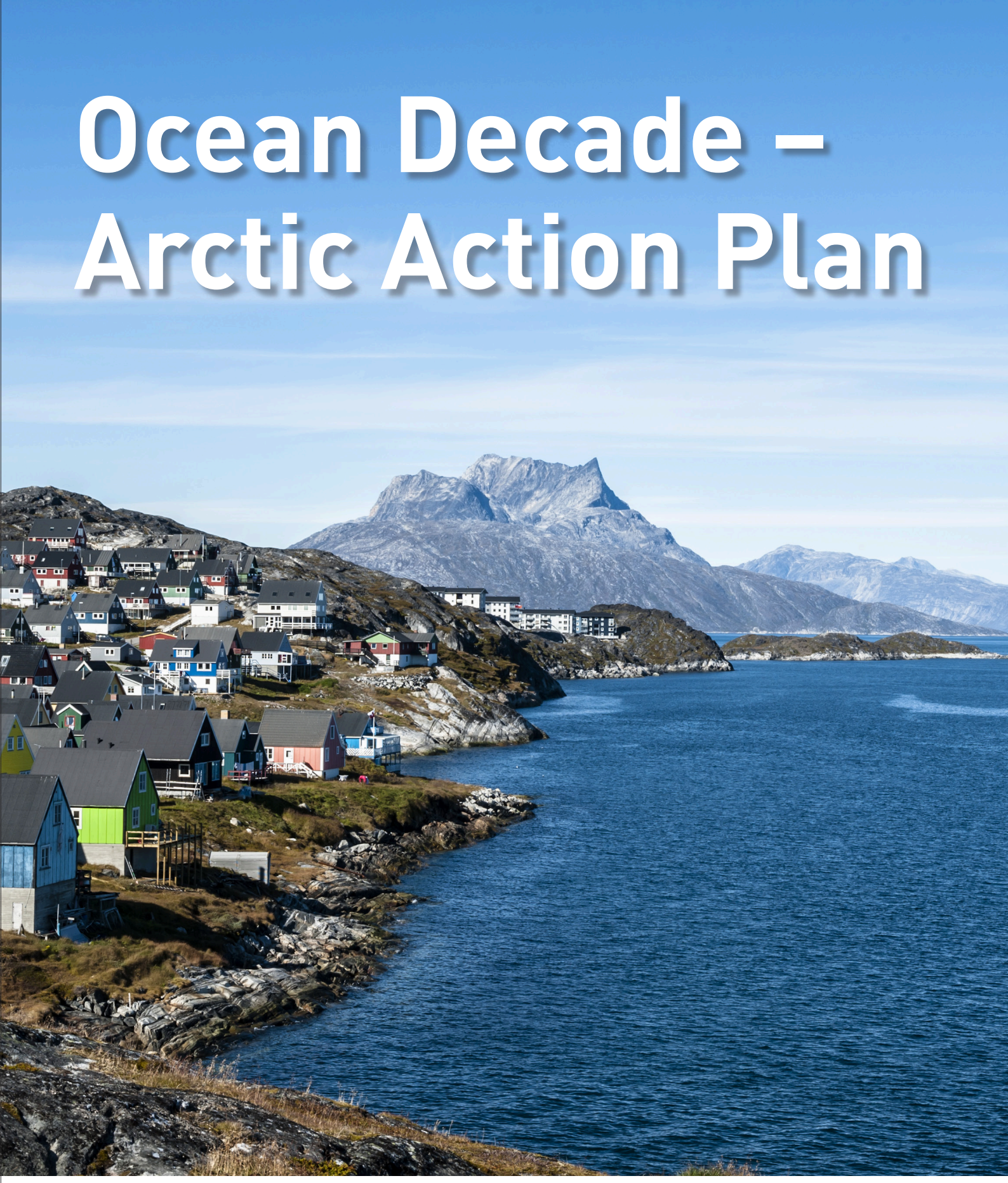
Ocean Decade – Arctic Action Plan



Danish Center for Marine Research

2021 2030 United Nations Decade of Ocean Science for Sustainable Development

CONTENTS

PROLOGUE

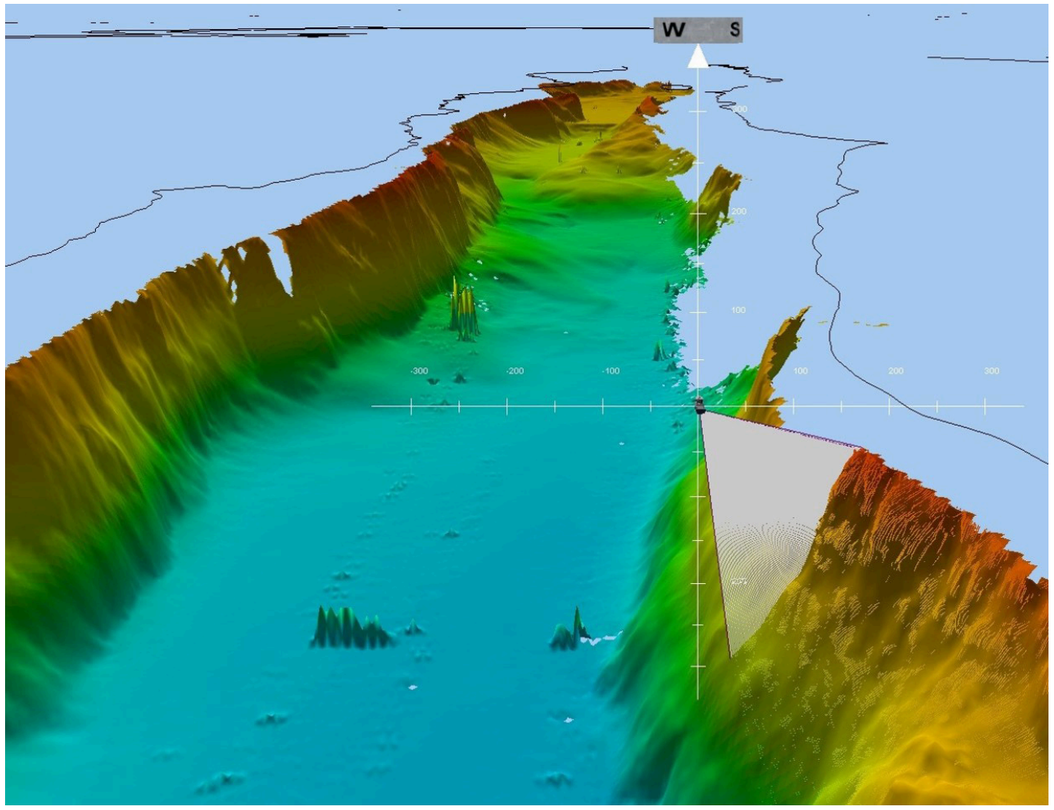
The United Nations Decade of Ocean Science for Sustainable Development (2021-2030) ('Ocean Decade') represents a transcendent opportunity to rally global scientific and societal capacities towards addressing pressing challenges for sustainable development. While the global ocean is continuous, sustainable development requires meeting highly complex regional challenges spanning environmental, economic, social political and legal dimensions. Actions to address these challenges therefore require coordinated implementation at global, regional and local levels, including in the Arctic and its diverse regions.

Based on the recommendations in the global Ocean Decade implementation plan and with support from IOC of UNESCO[1], a series of regional workshops were encouraged in order to inform the development of the Implementation Plan for the Ocean Decade and develop regional action plans. The initiative for the Arctic started with a one-day Policy - Business - Science Dialogue meeting in Tromsø, Norway hosted by the Research Council of Norway, as part of the Arctic Frontiers conference in January 2020[2]. This was to be followed by a three-day workshop in April 2020 in Copenhagen, Denmark hosted by the Danish Centre for Marine Research where the Action Plan was to be developed. Due to the COVID-19 pandemic, this was transformed into a series of online workshops held in October and November of 2020 for which working groups organized Action Plan development around the seven Decade Societal Outcomes established in broader UN Decade planning. More than 300 participants from industry, science, governments, NGOs, representatives from Indigenous Peoples, holders of Local knowledge and Indigenous knowledge, the broader global public (See Annex C summary of participant affiliations) discussed the barriers and scientific challenges for reaching sustainable development and potential science-based solutions that could help achieve them. This culminated in an online consultation in the March-April of 2021, where this plan was reviewed.

With the development of this initial Action Plan, we expect that the greater Ocean Decade community including Indigenous and local Peoples and other stakeholders will find inspiration and guidance to deliver transformative ocean science solutions for sustainable development in the Arctic. Built from a voluntary co-creation process that placed no formal restrictions upon participants, the Plan represents a global community driven effort with no formal ownership or legal mandate. This should be seen as a strength given the Ocean Decade's ambitions of creating the highest level of momentum from all corners of society. This momentum was recently on 9. May 2021 made clear through the endorsement of the Ocean Decade in the "Joint Statement of Ministers on the occasion of the Third Arctic Science Ministerial" signed by 23 ministers and representatives of Arctic Indigenous Peoples. Going forward, this inclusive approach has to be further strengthened, in particular in relation to engaging the full diversity of Arctic communities and interests through a process which both the Sustaining Arctic Observing Networks (SAON) and the International Arctic Science Committee's (IASC) Marine Working Group have indicated an interest in supporting.

The Arctic regions are now positioned to join the Ocean Decade

[1] Intergovernmental Oceanographic Commission (IOC) of United Nations Educational, Scientific, and Cultural Organization (UNESCO).
[2] Tromsø workshop outcomes link



BRIEF SUMMARY OF THE ARCTIC PROCESS

The ‘Ocean Decade – Arctic Action Plan’

This Plan aims to provide Arctic Peoples and stakeholders with a shared agenda that will implement actions that support the United Nations Decade for Ocean Science for Sustainable Development (2021-2030) (‘Ocean Decade’). The Ocean Decade is a global endeavour to create a significant collaborative momentum for ocean-related sustainable development and science. This Plan is the first regional action plan that was developed under the umbrella of the Ocean Decade. It presents a first wave of **challenges** to address in the Arctic regions. These challenges and the recommendations for actions to address them are expected to be updated throughout the Decade as our knowledge improves and the needs in the entire Arctic region change.

The target group

The target group for the Plan is broad, including the general global public and Arctic Indigenous and local Peoples but it is also relevant for strategic work that supports ocean science and accelerates sustainable development in the entire Arctic region via cultural sustainability concepts, research, marine ecosystem management, business development, policy and financial supporting mechanisms. These rights holders and other stakeholders are key actors in the global Ocean Decade given their role as decision makers at diverse jurisdictional levels, and are thus expected to take the initiative forward, acting to both fulfil the stated challenges and revising the plan during the decade with new actions to address missing or arising issues and challenges.

The Decade has a strong focus on co-design and co-delivery of ocean science by generators and users of ocean science – this means that non-scientific actors including industry, policy makers, managers and innovators are key targets of the Decade and the Action Plan.

The Decade also has a strong focus on diversity across geographies, genders and generations. There is a strong Early Career Ocean Professional network emerging through the Decade who will be essential to ensuring the sustainability and legacy of the Decade post-2030.

The Plan is not “owned” by anyone nor legally binding for any institution or government irrespective of their contribution to the development. All actors are however expected to respect and support the important role of Arctic Indigenous and local Peoples, comprehensively including their distinct rights and interests. This should be an integrated part of activities, projects and programmes, which presently constitute the different levels of Ocean Decade actions defined by the IOC Unesco.

The scope of the Plan

While the Ocean Decade is clearly tied to Sustainable Development Goal (SDG) 14 ‘Life below water’ and 13 ‘Climate action’, this regional action plan, as with the global implementation plan, aims to support progress towards all of the SDGs through the application of ocean science and Indigenous knowledge.

Geographically the regional plan spans the entire Arctic region encompassing coastal and oceanic waters and for consistency it is aligned with the marine area covered by ‘The Agreement on Enhancing International Arctic Scientific Cooperation[3]. This region is recognized as the distinct homelands and territories of multiple Indigenous peoples.

[3] The Agreement on Enhancing International Arctic Scientific Cooperation (2017). Available on: https://oaarchive.arctic-council.org/handle/11374/1916

The purpose of the Action Plan is to identify mechanisms towards achieving the Ocean Decade’s goals, which are defined as the following **Societal Outcomes**:

- A clean ocean where sources of pollution are identified, reduced or removed
- A healthy and resilient ocean where marine ecosystems are understood, safeguarded and managed
- A productive ocean supporting sustainable food supply and a sustainable ocean economy
- A predicted ocean where society understands and can respond to changing ocean conditions
- A safe ocean where life and livelihoods and their integrity are protected from ocean-related hazards
- An accessible ocean with open and equitable access to data, information and technology and innovation
- An inspiring and engaging ocean where society understands and values the ocean in relation to human wellbeing and sustainable development, and cultural integrity of Indigenous peoples reliant on the ocean and coastal seas.

To deliver this, the Arctic Action Plan development process has focused on answering of two key questions:

1. **What are the barriers that hinder progress towards achieving the Societal Outcomes of the Ocean Decade in the Arctic regions?**
2. **What transformative ocean science solutions will help overcome these barriers and how could they be implemented throughout the Ocean Decade?**

The Action Plan

The Arctic Plan development process produced a number of key insights, particularly related to the presence of **cross-cutting barriers for progress**. These challenges included scientific gaps in understanding and data availability, as well as organizational issues that inhibit efficient international coordination. This leads to the lack of tools and services that make new knowledge products accessible for industry, government entities, Indigenous peoples, and the public. To address these challenges, the plan has been structured around three types of challenges and recommended solutions to address them.

Research challenges – core scientific areas that should be advanced to enable the production of transformative ocean science solutions

Organizational challenges – devising effective strategies to provide and support efficient coordination, coherence, funding, infrastructure, data management and public support to activities in the regions throughout the year

Uptake challenges – options for enhancing and accelerating the societal utilisation and benefits of ocean science solutions in the Arctic regions and beyond

Research challenges – to achieve transformative ocean science solutions

The Ocean Decade's call for **transformative ocean science** can be separated into four overarching themes and transformative solutions for the Arctic regions. Each theme covers a list of specific challenges, which are suited for a dedicated research agenda as well as specific co-production development projects (Annex B).

Transformative Solution 1: Provide the entire Arctic region with a detailed open-access inventory of spatial and temporal information on bathymetry, oceanographic conditions, documenting geodiversity and biodiversity, disaster and pollution risks, provisioning of ecosystem services and their value to support evidence-based decision making.

Transformative Solution 2: Understand core Arctic climate and ecosystem dynamics; the impacts of anthropogenic pressures on the environment and ecosystem; and the mechanisms that threaten human health and safety in its regions.

Transformative Solution 3: Observe the state of Arctic environments and development trends in near-real time supported by information services that are tailored to the needs of Indigenous peoples, science, environmental management and industry. This includes co-designed sustained observation programmes to establish baselines and trends in: ice distribution and condition; weather and sea state; ecosystem structure and dynamics; biodiversity; distribution of natural resources; carbon cycling; anthropogenic pressures; ocean circulation; and spatial and temporal distribution of contaminants.

Transformative Solution 4: Predict and forecast Arctic climate and ecosystem dynamics on scales from hours to millennia, to enable climate adaptation, mitigation and ecosystem-based management of human activities.

Organisational challenges – for achieving high impact science in the entire region

There is a strong community awareness of the pivotal importance of international collaborations and organizational and institutional support to deliver high impact solutions in the Arctic. In particular efficient international coordination, adequate funding, infrastructure and equipment availability, data management and political support are core requirements. To emphasize this and catalyse progress, the Plan presents a dedicated agenda to advance these priorities, with details provided in the following pages.

- Connecting the Arctic region across all scales
- Establishing large-scale sustained and internationally co-funded programmes
- Collaborating and coordinating ongoing and future Arctic research, management and observation programmes from international to community level
- Collaborating on creating and maintaining joint open data sharing platforms.
- Co-designing and producing actions that link across local, national and regional boundaries
- Collaborating with key rights holders and other stakeholders throughout the Arctic to increase global awareness of Arctic issues and to ocean literacy in the entire region
- Developing technology to improve temporal and geographical coverage of multidisciplinary observation programs in the entire region throughout the year

Uptake challenges - to enhance societal benefit of ocean science in the Arctic

While ocean science is at the foundation of the Decade and hence also the Action Plan, the benefits arising from appropriate scientific research require dedicated actions to realise its full potential when utilised by government entities, industry, Indigenous peoples and their communities and society in general. To accelerate progress, the plan presents an agenda that highlights particular challenges that should be addressed. These challenges relate to the end of the 'knowledge value chain' where scientific progress is assimilated and transformed into tangible services and products and ultimately bringing society closer to the desired practical outcomes of the Decade.

- Developing the operational information services necessary to ensure safe navigation, in light of expected increase of shipping during the Decade.
- Developing Search and rescue (SAR) and oil spill response (OSR) capacity.
- Coordinated management and response to risks and disasters.
- Managing marine and coastal environments through an inclusive, integrated framework of actions
- Managing vulnerable habitats or threatened species through adaptive spatial planning including designation of Marine Protected Areas (MPAs) areas in collaboration and cooperation with Arctic Indigenous peoples.
- Managing marine and coastal areas with responsive enforcement measures.
- Collaborating with key rights holders, industry stakeholders and governments to create an Arctic-Specific Corporate Social Responsibility (CSR) program.

THE NEED FOR AN OCEAN DECADE - ARCTIC ACTION PLAN

Photo: Lawrence Hislop

The Arctic region is centred upon its marine environment, which is currently experiencing rapid and dramatic changes as a consequence of climate change. These changes are impacting communities and ecosystems but they also have regional and global implications for industries, governance, society and the earth system itself. In this light much is at stake for a broad range of stakeholders among who Indigenous and local Peoples have a distinct role as rights holders in the Arctic regions.

Some of these changes present threats and challenges while others provide new opportunities for sustainable development of the region. An underlying requirement is that relevant rights holders and other stakeholders collaborate to harvest the full potential of Indigenous knowledge, science and technology in order to ensure optimal social, economic and environmental outcomes and to ensure the best available knowledge to base decisions and policy upon.

In recognition of the potential of the oceans for supporting sustainable development, the United Nations has launched the Decade for Ocean Science of Sustainable Development (the Ocean Decade, 2021-2030), which will provide a unifying global framework for supporting and communicating transformative ocean related actions to support sustainable development. Over the coming ten years the decade is anticipated to mobilise new opportunities for collaborations and partnerships among coastal, marine and maritime rights holders and stakeholders, based on a shared understanding of the need for joint global efforts to achieve the Sustainable Development Goals for all regions of the world. In terms of the Ocean Decade, this is translated into the achievement of the Decade's societal outcomes as defined in the global implementation plan (Figure 1).

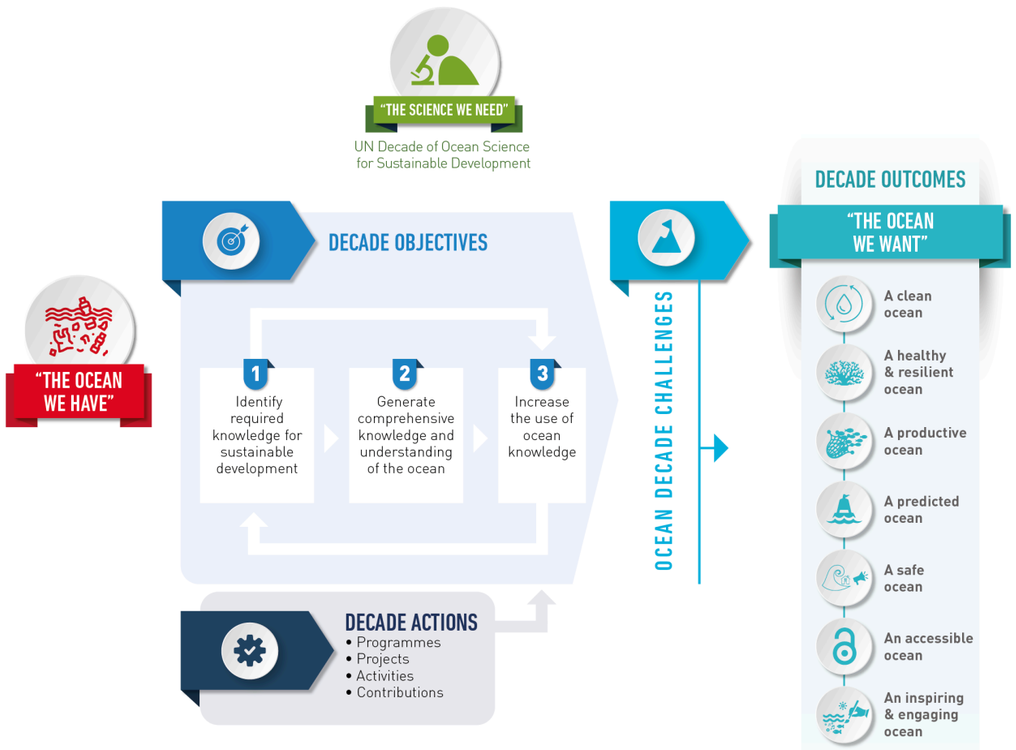


Figure 1: Objectives and Actions of the Ocean Decade

From an Arctic perspective, the Ocean Decade therefore presents an opportunity to rally global scientific and societal capacities around a regional ocean system with pressing challenges and opportunities.

To seize this opportunity, IOC UNESCO has encouraged the development of international efforts to lead a bottom-up process at regional levels[4]. The aim is to develop regional Action Plans that clearly describe how the envisioned Societal Outcomes of the Ocean Decade may be achieved through science-based actions.

The key ambition of this 'Ocean Decade - Arctic Action Plan' is therefore to:

- Provide all rights holders and stakeholders with a shared perspective on how to interpret and translate the objectives of the Ocean Decade in an Arctic-specific context
- Provide a consolidated list of high-level challenges for the entire Arctic region that should be addressed as a part of the Ocean Decade as rights holders and stakeholders align their efforts and draft partnerships in support of the decade

Fortunately, cross-border international collaboration on policy, science and innovation already has high-level support in the countries located in the Arctic[5]. Additionally, there are well established Arctic Indigenous peoples organizations that transcend national borders. Given these enabling structures, the Arctic Ocean Decade plan provides a clear path for the significant roles that Arctic regions are poised to play during the Decade.

This role of the Ocean Decade in the Arctic regions has further received high level confirmation on 9. May 2021, in the "Joint Statement of Ministers on the occasion of the Third Arctic Science Ministerial" signed by Canada, the Kingdom of Denmark – representing Faroe Islands and Greenland – Finland, Iceland, Norway, Russia, Sweden, and the United States, Austria, Belgium, China, Czech Republic, France, Germany, India, Italy, Japan, Republic of Korea, the Netherlands, Poland, Portugal, Singapore, Spain, Switzerland, and the United Kingdom, European Union, and Arctic Indigenous leaders from the Arctic Indigenous Peoples Organizations: Aleut International Association, Arctic Athabaskan Council, Gwich'in Council International, Inuit Circumpolar Council, Russian Association of Indigenous Peoples of the North, and Saami Council.

[4] See Annex A for a description of the Arctic Action Plan development process.

[5] Agreement on Enhancing International Arctic Scientific Cooperation negotiated under the auspices of the Arctic Council and ratified by the eight Arctic states. https://oaarchive.arctic-council.org/handle/11374/1916

IDENTIFIED KEY CROSS-CUTTING BARRIERS TO OVERCOME

During the Arctic consultation process multiple barriers for progress towards the Decade's goals were identified. Many of these barriers are not unique to the Arctic and almost all were cross-cutting in nature when considered by the working groups assembled to consider limitations for meeting the societal outcome.

Barrier 1: A disconnected Arctic

In a disconnected Arctic, Indigenous peoples, communities, industries, science and governments are hindered from benefiting from collaborative efforts. This creates a risk of: i) duplication or even counterproductive efforts; ii) misunderstanding of local needs and culture; iii) sustained regional inequality with respect to societal development; iv) missing the opportunity to benefit from experience and achievements from other regions (both within the Arctic and beyond); and v) marginalization of Indigenous peoples reliant upon the Arctic marine environment for millennia. A prerequisite for progress is an increased focus on removing communication and connectivity barriers within the Arctic and across the diverse domains of physical, digital and human infrastructure. This also relates to the challenge of data sharing, where governmental barriers can hinder exchange of information[6].

Barrier 2: Insufficient means to ensure safety and health in the Arctic

The Arctic is composed of remote and diverse regions where conditions are changing and where people and infrastructure are often confronted with significant risks. A key challenge is to provide the entire Arctic region with the means to understand, map, manage, and respond to the inherent risks related to the Arctic marine and coastal environment and its changing nature. Current risks can be broadly categorized as including threats from terrestrial and sub-marine hazards, adverse impacts upon marine biodiversity, poor predictability of weather, varying sea and ice conditions, delayed response to environmental and human emergencies, exposure of local population and ecosystems to local and long-range sources of pollution, and illegal or unregulated exploitation of natural resources. Understanding and addressing these risks should thus help secure a safe future for Arctic Indigenous peoples and residents and the natural systems they are a part of.

Barrier 3: Inadequate knowledge of the value and distribution of resources

Arctic regions contain considerable cultural heritage and natural resources, of which some remain poorly understood, undiscovered, under-appreciated or even unknown to the global population. Little is known about the present and future location of resources and their value both economically and culturally. Providing the Arctic regions with a common detailed inventory of present resources and scenarios for future access and efficient use is an important step for development in the entire Arctic area. The availability and communication of this knowledge broadly is an important step to enable local decision-making as well as increasing the global awareness of region and its importance culturally, economically and climatically. The relationship between Indigenous peoples and environment and natural resources must be understood and included in overcoming this barrier.

[6] Recent developments such as the Agreement on Enhancing International Arctic Scientific Cooperation negotiated under the auspices of the Arctic Council, provide a science-diplomacy track towards resolving aspects of the issue.

Identified key cross-cutting barriers to overcome

Barrier 4: Inadequate management of Arctic marine ecosystems

Much of the Arctic's natural capital and its related ecosystem services are linked to the marine environment and are the foundation upon which much of the development potential and cultural heritage rests. It is therefore important to understand and manage the impact of local, regional and global activities on Arctic marine ecosystems. Providing the entire Arctic region with the means for adaptive ecosystem-based management relies on understanding individual physical, chemical, geological, and biological components and the interrelations and interactions among them on various time scales. This can then be combined into both national and international strategies where targets are set, systems are monitored, predicted, and assessed, new knowledge is integrated, and achievements are recognized and evaluated. With these advances, the potential emerges to develop long-term socially sustainable blue and green economies in the Arctic with positive environmental, economic and cultural outcomes.

Barrier 5: Inadequate support to the Arctic regions

The Arctic is integral to global environmental stability and as such, there is a shared global interest in understanding the status and trends in the Arctic environment and supporting its present and future management. Changes in the Arctic cryosphere and thermohaline circulation will have an effect on the global climate, but the resolution to this global challenge is not to be found within the Arctic. Similarly, several of these changes will likely act as pressures on the Arctic region's unique biodiversity and other natural resources. However, in comparison to other areas that are rich in natural resources, few people inhabit the Arctic and most Arctic natural resources are exported to the south. In addition, the intensity and the type of use are anticipated to change as the seasonal sea ice retreats, opening new opportunities for shipping, fisheries, mining, petroleum extraction activities and the further development of other economic forces including tourism. Thus, not only local Arctic Indigenous peoples and other communities but also non-Arctic nations have a direct interest in ensuring the sustainable development of the entire Arctic region. Overcoming barriers related to support for initiatives in the Arctic regions, is therefore a shared global responsibility, and should be considered a mandatory step towards supporting the fulfilling of sustainable development goals.

THE ARCTIC ACTION PLAN

Photo: Leif Bolding

The sustainable development challenges facing the entire Arctic region and its marine and coastal areas, societies and industries are diverse. Some issues require scientific progress, while others relate to sharing and alignment of work efforts and data in an institutional context. Others cover complex issues related to collaboration on international governance that is in the end a political enterprise. Specifying tangible approaches for actions is therefore a difficult task. In an attempt to overcome this, the Plan presents three overarching areas that have a dedicated agenda of specific challenges, supplemented with recommendations regarding implementation in an annex. The three areas are:

Research challenges – the core scientific areas that must be advanced to enable the production of transformative ocean science solutions

Organizational challenges –providing and supporting efficient and inclusive coordination, funding, infrastructure, data management as well as increasing public support for activities in the Arctic regions throughout the year

Uptake challenges – the options for enhancing and accelerating the societal assimilation and benefits of ocean science solutions in the entire region

Among these challenges are elements that are highly cross-cutting. These include:

- The essential need for effective and direct involvement of Indigenous Peoples and local communities in the Arctic, and
- Collection, management and sharing of data

Both of these issues have already been identified in multiple international initiatives on science and sustainable development, but these issues remain to be resolved and need to be explicitly addressed throughout the Ocean Decade. Both issues were emphasised by all working groups and consultations carried out in preparation of the Action Plan. In particular, there is a need to strengthen pathways for incorporating local and Indigenous knowledge into policy decisions. In addition, building capacity within governments, organizations and with individuals will facilitate awareness of other forms of knowledge that are available, and what best practices are required for co-designed actions and solutions. Progress on this is consistent with the Ottawa Traditional Knowledge Principles[7], as well as the UN Framework Convention on Climate Change (UNFCC) including Paris Agreement on Climate Change and other international instruments, all of which identify a need to strengthen knowledge, technologies, practices and efforts of local communities and Indigenous Peoples in addressing and responding to climate change, as well as incorporating Indigenous knowledge systems into political, social, cultural, economic, and environmental policies, actions and decisions.

While both of these cross-cutting topics are presented as explicit challenges in the Plan, they should also be considered embedded as elements in many other challenges. In relation to data acquisition, management and use, this means, for example, that all stakeholders would benefit from acknowledging the need to address the entire data value chain from data production/collection systems to data management systems to data use in products/information in all challenges.

Research challenges – to achieve transformative ocean science solutions

The Ocean Decade's call for transformative ocean science, can for the Arctic regions be divided into four overarching solutions each comprised of a subset of research challenges:

[7] Ottawa Trad. Know. Principles https://www.arcticpeoples.com/knowledge#indigenous-knowledge

TRANSFORMATIVE SOLUTION 1:
Provide the entire Arctic region with a detailed open access inventory of data and information

The inventory should include spatial and temporal information on bathymetry, oceanographic conditions, presence of geodiversity and biodiversity, disaster and pollution risks, and provisioning of ecosystem services and their value. The aim is to enable transparent evidence-based discussions and decision-making concerning which areas and resources should be managed in particular ways and by whom

Research challenges include:

A) Discovering the natural capital geodiversity and biodiversity, and establishing where Arctic landforms, seascapes, wildlife, fisheries, plants and biological richness in general contributes to the welfare of people within and outside the Arctic

It is important to identify where and when ecosystem services are provided throughout the Arctic and who the beneficiaries are both regionally and globally (through for example climate services). This includes seabed and habitat mapping activities, assessment of the distributions and migration of living marine organisms throughout the Arctic and neighbouring seas. The aim is to understand connectivity and the demand for shared management of key resources such as fish and marine mammals. The central role of Indigenous knowledge and corresponding safeguards for its use must be recognized. New observational technologies can be adapted and exploited to open the possibility for new and more efficient data collection and to fill knowledge gaps including in the central Arctic Ocean. This will support integrated ecosystem assessments and leverage the ongoing efforts by regional science planning and coordinating organisations[8].

B) Map the present and future value of Arctic ecosystem services and how they are valued within and outside the Arctic

This challenge relates to advancing knowledge frameworks and systematic mapping and consensus-based analyses of the 'value' and the way people 'value' Arctic natural systems. This effort will need to bridge value systems by advancing analysis of both use and non-use values[9]. This should include documentation and integration of Indigenous knowledge and local knowledge about ecosystem services, associated cultural values and other practices that are not well understood or considered in both historical and contemporary contexts. Efforts are needed to ethically and equitably accept Indigenous, local and scientific knowledge as each having significant value for communicating and understanding relevant policy levels. As a part of these initiatives, mapping efforts should include both present resource uses and the prospects for increased Arctic development and resource use. This should also support:

i) The identification of areas where activities by one sector or rights holder may reduce or increase value for other sectors or rights holders including options for reducing cross-sector conflict trade-offs or increasing synergies (i.e. using spatial planning principles).

ii) The identification of forgone value resulting from poor or misinformed management — i.e., what have been and are continuously lost by failing to practice integrated ecosystem management, including the failure to invest in observation programmes that support those goals.

[8] Including for example AMAP, ICES, PAME, PICES and CAFF
[9] as suggested by IPBES (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services)

iii) Moving beyond extractive industries through the identification of the potential for growth in sustainable industries and their implications for Arctic communities and Indigenous peoples.

iv) The understanding of how international agreements or conflicts affect value and management, particularly considering the impacts of species range shifts, and other altered ecosystem services

C) Identify risks to human health in the Arctic and enabling cross-sectoral risk management

This challenge relates to risks understood in a broad sense from disaster risks such as geo-hazards (e.g. tsunamis), shipping, or risks associated with pollution and other human activity. These risks should be assessed both individually and cumulatively, with emphasis on discovering and characterizing those that have previously been ignored or underestimated and those specific to the characteristics of Arctic ecosystems and communities. The scope of this challenge should include:

i) where and when climate change should be considered to be a threat to infrastructure, facilities, disaster prevention or response operations

ii) connections across regions and ecosystems that potentially expose human health and vulnerable ecosystems and impact ocean health

iii) how environmental and social developments affect risk and risk management including the role of area-based measures including protected areas and shipping

iv) how to best ensure recognition of risks facing Indigenous peoples and their communities and identify best practices in risk management, including food safety and food security

TRANSFORMATIVE SOLUTION 2:
Understand the core Arctic climate and ecosystem dynamics.

A transformation is needed in order to better understand the impacts of anthropogenic pressures on the environment and the mechanisms that threaten human health and safety, allowing regional and global rights holders and stakeholders to understand why and how the environment, human opportunities and threats are changing.

Research challenges include:

A) Understanding the Arctic ocean-climate nexus and ecosystem dynamics

Sustainable development in the Arctic requires an enhanced understanding of the physical, chemical, geological and biological earth system components and, the links and interactions between them, including that between land, ocean and atmosphere. With this enhanced understanding in hand, past, current and future climate change and its impact on society can be resolved. Research should address:

i) The knowledge gaps for understanding climatic, biogeochemical and ecosystem processes and tipping points, which may lead to both regional and global change.

ii) The diversity, status and resilience of Arctic ecosystems in order to uncover new or lesser understood ecological processes or to better resolve their quantitative importance in different parts of the Arctic.

iii) The development of new approaches and technologies for observing and resolving physical, chemical, geological and biological aspects of the Arctic marine environment.

iv) The identification of key variables and observing requirements for observation programs which can best support the development and operation of predictive models.

B) Understand how anthropogenic pressures impact environmental health and resilience

This challenge involves the identification and mapping of known and emerging anthropogenic pressures and the quantification of their impact on key ecosystem components and functions. It should support research towards:

i) Understanding toxicity of contaminants and cumulative impacts of pressures.

ii) Identifying ecological tipping points and the relationship between pollution and climate change, in order to help quantify future impacts on the Arctic system from pressures originating from both within and outside the Arctic.

iii) Delivering a knowledge foundation to contribute to policy level actions related to prevention of local pollution sources or activities (e.g. waste incineration, run-off from dumpsites, nuclear fuel cycle pollution, increased shipping activity and noise).

iv) Resolving policy barriers and potential measures for mitigating the impacts of these pressures.

TRANSFORMATIVE SOLUTION 3:
Observe the state and trends of Arctic environments in near-real time supported by information services tailored to the needs of Indigenous peoples, communities, science, environmental management and industry.

The solution should include the creation of distributed sustained year-round observation programmes to establish baselines and trends in sea-ice; weather conditions and sea state; ocean and coastal circulation; ecosystem structure and dynamics; distribution of living and non-living resources; carbon fluxes; anthropogenic pressures; and spatial and temporal distribution of contaminants. Timely quality assured observations are mandatory for assimilation into and validation of models as well as validation of satellite observations. This will provide Indigenous and local Peoples and stakeholders a better foundation to understand and respond to ongoing environmental change and risks.

Research challenges include:

A) Observe the state of the Arctic environment, its anthropogenic pressures and human activities and track changes through an integrated and sustained pan-Arctic observation programme[10]

To understand how the rapid changes unfold in the Arctic marine and coastal ecosystems, baselines must be established, and developments followed via sustained observation of key atmospheric, oceanographic, geophysical, glacial, biogeochemical and ecological parameters. In addition to natural processes these in-situ and remote observational needs also include monitoring of social and economic indicators of the ecosystem, including those related to

[10] This challenge is further tightly linked to the Organisational Challenge 3: Collaborating and coordinating ongoing and future Arctic research, management and observation programmes

anthropogenic pressures and the human activities that generate them. Databased knowledge from sustained observations fuels development, initialisation, assimilation, and validation of theoretical, operational and climatic models. These are in turn used for operational forecasts and assessments covering a full range of timescales that are relevant to society, management, industry and scientific activities. Thus, observation programs provide the foundation for many efforts related to regional and global sustainable development. Activities should recognise existing observation activities and advance:

i) Establishment of a distributed pan-Arctic observation programme. Data collection must span the atmosphere, hydrosphere, geosphere, cryosphere and biosphere (e.g. including an agreed-upon inventory of essential Arctic ocean variables at defined spatiotemporal resolutions, quality and timeliness) in combination with social and economic activities (shipping, fisheries, tourism, mining etc.) and anthropogenic pressures (contaminant and noise levels etc.) to allow interdisciplinary analysis at the system level including processes as feedbacks impacting components of the Earth System beyond the Arctic. The programme should span in-situ observation as well as remote sensing satellite-based missions to cover all relevant aspects.

ii) The continuity and the development in the synoptic earth observation (i.e. satellite based observation) availability, especially for monitoring of sea ice coverage ensuring sufficient overlap periods of service, and thereby limiting observation gaps and data consistency.

iii) Increased deployment of autonomous Arctic observing platforms, delivering temporal and geographical resolution necessary to support model development and identify new processes and connectivity across the Arctic marine environment. These will represent an important supplement to more comprehensive but non-continuous ship-based observations.

iv) Increased acquisition of paleo-oceanographic observations that are critical for establishing natural reference/baseline conditions and the validation of climate models developed for prediction of future scenarios.

v) Development of internationally coordinated synoptic multidisciplinary ship-based field sampling activities throughout the year, to provide comprehensive in-situ datasets of standardized measurements not available from autonomous platforms.

TRANSFORMATIVE SOLUTION 4:
Predict and forecast Arctic ecosystem and climate dynamics.

This predictive capacity should cover time scales from hours to millennia, to provide Indigenous and local people and other stakeholders with the ability to identify preferred ecosystem-approaches to human activities and climate adaptation strategies

Research challenges include:

A) Development of purpose-built forecasting tools for society, industry and management to guide evidence-based decision-making

The capacity for robust predictions of specific aspects of the future is essential for drafting strategies dedicated to achieving safe and sustainable development. This will aid evaluation of the potential for new industrial ventures, efficiency of new regulations or policies, and the impact of anthropogenic activities. This challenge draws on tools based on geological, historical and real-time data sets from paleo-archives, in-situ observations and satellite remote sensing to be

assimilated in and to validate models. Recent methodological developments, including artificial intelligence, will likely be relevant to advance the area. Development should revolve around the following priorities:

i) Tools enabling timely and operational high-resolution sea-ice charting and forecasting including ice thickness to support efficient and safe navigation, search and rescue, and research on ecological impacts

ii) Tools for predicting impact of Arctic sea ice loss on extreme weather events over the mid-latitudes and the impact of Greenland Ice Sheet melt on sea level rise, ocean circulation and storm tracks in order to support climate adaptation strategies of governments, communities and industries

iii) Tools to assess impacts of anthropogenic pressures on Arctic biota and human health. This should cover both known and emerging pressures such as fisheries impact and pollutants ranging from radionuclide and chemical pollution, including plastics, to anthropogenic noise, and enable identification of relevant management responses. The priority includes development or adaptation of models to predict consequences of cumulative stressors acting at different spatial and temporal scales.

iv) Tools for ecological forecasts. This should include hindcasts, current conditions, sub-seasonal and seasonal-to-inter-annual forecasts and long-term projections (decadal to multi-decadal) of ecosystems. These tools should also address the status and trends of living marine resources in order to support climate adaptation and to assess scientific advice on sustainable resource exploitation.

Organisational challenges – for achieving high impact science in the entire Arctic region

International collaboration and organisational support is critically important in the Arctic in order to deliver high impact solutions. In particular, this includes efficient international coordination, adequate and sustainable funding, infrastructure and equipment availability, data management and political support.

1) **Connecting the entire Arctic region**
Communication within the Arctic faces many barriers due to limited transportation, internet access, low population densities and often challenging weather, among many other factors. This reduces the ability of non-Arctic residents to engage Arctic communities, as well as Arctic Indigenous and local Peoples to share their knowledge, ideas, world views and priorities, both within the region but also beyond. The lack of communication infrastructure reduces the access to information, education and the viability and safety of operations across industry and society where data on real-time conditions are needed.
To advance collaboration in the region, there is a need to support efforts to connect the Arctic region both within the region and with the rest of the world. Support includes the provisioning of key information technology, in particular internet coverage with adequate bandwidth to provide near real time data-transfer, and the necessary digital and human infrastructure and skills. This should also include supporting data exchange between nations and will help address the research challenges enumerated in the Plan. Large-scale global organisations, regional

organisations, including Indigenous peoples and the scientific community could play a key role in addressing this challenge, as a highly relevant cross-cutting goal for the Decade.

2) **Establishing large-scale sustained internationally co-funded programmes**
For most stakeholders, be they private local businesses, scientific institutions, industry or government agencies, the Arctic is expensive to operate in. Development programmes are often short-term and investments sporadic, though progress has been seen in some areas such as remote sensing. This creates gaps in key datasets such as those needed for the development of forecasting services for Indigenous peoples and their communities, local communities, industry, science and management, which in turn reduces the likelihood for gains through international coordination and sharing of technology, data, infrastructure and human capacity. These conditions reduce the opportunity to align national research and innovation priorities and undermines sustained development of strategic long-term transboundary partnerships. Combined, these conditions impact both the regional ability to support sustainable development and also global progress for understanding environmental and climate changes and the requirements for necessary adaptation.
To advance progress in the entire Arctic region, there is a need to support steps towards the creation of large-scale sustained internationally co-funded programmes related to observation, research and management. Support includes the long-term shared commitment by funders who believe sustainable development should be a priority in the Arctic. Support must be built on the shared acknowledgement that large scale Arctic cooperation is needed to understand both the regional and global climatic and environmental system developments. This requires dedicated commitments from nations, rights holders, stakeholders and private foundations[11].

3) **Collaborating and coordinating ongoing and future Arctic research, management and observation programmes**
The benefits of coordinated collaborative activities in the Arctic far outweigh the challenges. These benefits include sharing of both physical and digital infrastructure, and transparent sharing of data, which is commonly characterized as being based upon findability, accessibility, interoperability, and reusability (FAIR)[12]. While these efforts lead to human capacity building and exchange of information, scientific synergies and coordination, significant efforts are required with regards to collaboration. This includes alignment of efforts among diverse stakeholders from the planning phase to execution and curation of end products and data. Such initiatives will benefit from recognition of and respect for Indigenous peoples and their knowledge holders, collaborative activities; such contributions cannot be underestimated and must be included.
To advance progress in the entire Arctic region, there is a need to increase support for collaboration and coordination of ongoing and future Arctic research, management and observation programmes. Coordination involves bringing together both regional and international programme owners to map and communicate their short-term and multiannual research and observation programmes in time and space. Collaboration should include all relevant efforts (e.g. pollution, climate, geo-hazards, geo- and biodiversity, economic activities), standardisation of data collection and sharing (FAIR), management and reporting. Collaboration at this level should provide a steppingstone for future internationally co-developed frameworks for pan-Arctic integrated observation programmes before the end of the Ocean Decade. Current

[11] The newly established Arctic Science Funders Forum (ASFF) could be developed to play an important role in the coordination of arctic research.
[12] Wilkinson et al. (2016) https://www.nature.com/articles/sdata201618

top-down efforts[13], and bottom-up initiatives[14] should be recognised and provide inspiration and experience for the development of an integrative framework including non-Arctic nations and Arctic inhabitants, including Arctic Indigenous peoples. The formulation of observing system requirements should be a natural first step to identify gaps and prioritise future efforts.

4) **Collaborating with key rights holders and stakeholders on creating and maintaining joint open data sharing platform**
Due to the value of Arctic data for a diversity of rights holders and stakeholders, there is a need to overcome the challenges of making both historic and future data available and accessible. This can be facilitated through the development and maintenance of a joint open data platform for sharing direct access to data from distributed repositories. This will need to address the present governmental barriers for example related to bathymetry, which are presently preventing data sharing with third parties. In relation to Indigenous knowledge, the rights, guidelines, protocols, values, and institutions of Indigenous peoples will be recognized, protected and maintained. Similarly, such a data sharing platform should span all domains (environmental, social and economic data) to ensure the widest possible relevance to knowledge production, science, industry and society and be built on FAIR and CARE principles[15]. A key ambition should be centralized data access to an interoperable platform. An appropriately designed platform will facilitate standardized products for selected core data sets that assess changes over time and space, including the capacity to monitor the response of the Arctic system to complex and multiple stressors. The platform will also ideally facilitate services and applications exploiting data from repositories and ultimately offer integrated analysis and forecasting services (developed in an open access environment). Operationalisation should be further supported by open metadata, and allow users to search for existing monitoring efforts in three dimensions:

- o Spatial extent, scale and resolution (seen as a map)
- o Time scale and resolution (up to real-time)
- o Environmental variables and human activities

5) **Co-designing and producing actions linking across local, national and regional and international peoples and communities**
Indigenous Peoples and local communities possess invaluable knowledge of local conditions, past and current environmental changes, and societal needs and capacity. That knowledge, accumulated over thousands of years in the Arctic, has been inadequately reflected in many decision-making processes. Decision makers and scientific experts are only recently beginning to appreciate how Indigenous Knowledge can and should inform their activities. Where decisions have been informed by Indigenous knowledge and scientific (e.g., the establishment of large marine protected areas in the Canadian Arctic), the results have been stronger and led to more broadly embraced policies. Concerted efforts to build on such successes are needed to more consistently and equitably inform decisions with co-produced knowledge. The non-Indigenous Ocean Decade stakeholders, particularly those not residing in the Arctic, should acknowledge these realities and be required to develop actions that have been actively and directly co-designed by people in the Arctic so that actions will reflect their priorities and concerns in terms of outcomes and approaches.

[13] For example working groups established under the Arctic Council.
[14] For example scientist-based initiatives such as Synoptic Arctic Survey (SAS) and Distributed Biological Observatory (DBO).
[15] FAIR (findable, accessible, interoperable and reusable); CARE (Collective benefit, Authority to control, Responsibility and Ethics)

6) **Collaborating with key rights holders and other stakeholders throughout the Arctic on increasing the global awareness of Arctic issues and ocean literacy in the entire Arctic region**
In order to gain support for sustainable international development in the Arctic, international awareness must be increased regarding the global significance of the Arctic in relation to climate, biodiversity, and cultural importance. Similarly, it is a challenge if Arctic communities, which are diverse in needs and vulnerabilities, are not provided with the most updated knowledge on developments in their regions and the related hazards and opportunities that affect coastal and marine activities. Ocean Decade rights holders and other stakeholders should acknowledge this responsibility and strive to develop collaborations focused on education related to ocean literacy, community-based environmental monitoring and Arctic economic, social, cultural and political awareness, bridging local to regional efforts across all age groups.

7) **Developing technology to improve temporal and geographical coverage across different data types**
The inadequacy of Arctic data within many domains can to a significant degree be explained by the difficulties and expense related to environmental observations throughout the year and seabed mapping. To address this, future Ocean Decade collaborations should support the development of a new generation of fit-for purpose polar hardened technology that can not only withstand often harsh Arctic conditions, but also be operated to an increasingly remote degree. It could include state-of-the-art and emerging remote-sensing technologies, robust automated measurements, non-intrusive instrumentation, but also improvements in existing technologies aimed at reducing the environmental footprint of observation activities. As further advancements occur in near real time data transfer, including from under-ice autonomous navigation and communication devices, these advanced data platforms will better support operational modelling and forecasting.

Uptake challenges - to enhance societal benefit of ocean science in the Arctic

While findings from ocean science are key to an enhanced understanding of the Arctic and the benefits arising from it, dedicated actions are needed to achieve their full potential across management, industry and society at large. This is particularly true in the Arctic where current environmental changes are creating an increasing demand for adaptive management frameworks that can be supported by agile organisations. The goal should be to overcome the long reaction times of 'classic' management mechanisms and agreements that could slow down progress toward sustainable and effective solutions. To accelerate this transition, several dedicated challenges should be addressed that contribute to the 'knowledge value chain' where scientific progress bridges a gap into tangible services and products for rights holders and stakeholders.

1) **Developing operational information services necessary for safe navigation**
Navigation in the Arctic demands support to identify potential hazards and inherent risks, which are exacerbated by lack of aids to navigation, limited infrastructure, remoteness, communication barriers, and harsh conditions of the entire Arctic region. Much of the information and facilities required to plan and conduct safe navigation, which is often commonly available for other regions, is lacking in the Arctic.

To address this challenge, there is a need to enhance current national capacities to update and expand on data required for the safe navigation and in line with international requirements for ships, such as the SOLAS and the IMO Polar Code. Further there is a need to develop an institution/platform charged with compiling and coordinating the information for improved voyage planning and provide the following services and products:

1) Up-to-date navigational charts, with clear presentation of sensitive areas to be avoided such as strictly protected areas.
2) Operational services providing near real-time information and forecasts on weather, ocean conditions (currents, waves, temperature) and sea ice distributions, concentration and thickness and iceberg.
3) Maritime pilots and their availability.
4) Navigational issues supported by local knowledge.
5) Information on proximity to port of refuge.
6) Bunker options.

An international effort should be made, whereby international organizations, such as IHO, together with national Administrations can expand their survey programs to provide the information needed for ships. A joint centre may be established broadcast information for maritime navigation, and which would identify systematic identification of data gaps or validation requirements.
This challenge would likely be addressed efficiently through the development of a one-stop service that could distribute information required for any specific voyage planning task.

2) **Developing SAR and OSR capacity**
The quality and coverage of Search and Rescue (SAR) and Oil Spill Response (OSR) is a pan-Arctic challenge for safety and environmental protection, because of a lack of distributed infrastructure in the entire Arctic region. SAR is and has always been dependent on nearby resources being able to reach and provide an adequate response to any specific incident. OSR has the same challenges and for a successful response, nearby resources and fast reaction is imperative. Onshore resources are limited and, in some areas, basic survival needs like food, water, access to hospitals and/or doctors could be in short supply in event of a mass casualty. Furthermore, there is a need to better integrate the needs and capacities of local communities and Indigenous peoples in the overall approach to Arctic SAR and OSR as these groups have often not been consulted or effectively included. From a disaster risk reduction perspective, this is a serious problem as disaster risk mitigation and preparedness have been shown to be considerably more effective when there is a higher level of public engagement. This is even more true considering that formal disaster governance mechanisms are not always well-organized in the Arctic, and local populations are often required to deal with their own disaster risk reduction and response needs. Several gaps therefore remain before response options are up to international standards.
From an ocean science perspective, SAR and OSR operations present dedicated challenges in the entire Arctic region. These challenges include for example the dependence on the availability of high quality local and remote sensing observations to support modelling of the ice, ocean and sea state variables. It also includes analyses of, for example, whether very low sulfur fuel oil (VLSFO) as a polluting substance may require different responses than the traditional HSFO,

which is being phased out. Environmental impact assessments of response methods and derived effects are therefore a relevant emerging research area to advance best practises.
It would be most ideal if information related to safe navigation also enhances environmental intelligence that would be applied to identify response options. This should particularly focus on exploiting coordinated use of commercial vessels of opportunity in emergency response scenarios to better cover huge geographical areas. Similarly, knowledge of local community capacities could lead to them playing a greater supporting role in operations following provision of hardware, response equipment, and training related to medical and oil spill responses.

3) **Managing and responding to risks and disasters**
As the mapping and understanding of Arctic disasters, risks and hazards progresses (see Research Challenges), the potential for responding efficiently increases. This progress will, however, not happen if the relevant rights holders and stakeholders are not provided with this information, and in a format tailored to their needs. Translating this scattered knowledge, providing supporting tools and documenting best practices therefore constitute a dedicated challenge in need of several specific lines of actions including:

   i) Establishment of a task to collate, translate, merge and distribute data and hazard mapping from across the Arctic to support the ability of local authorities, governments, industry, local communities and Indigenous peoples' communities to plan and respond adequately to disasters and risks. This could take the form of a Pan-Arctic multi-hazards knowledge hub addressing disasters and longer-term transnational risks with representation from Arctic nations, local authorities, including Indigenous peoples and their institutions, business, national science bodies, environmental agencies and universities. Broad inclusive representation will be important as the perspectives on risks and responses are anticipated to be diverse given the heterogenic nature of Arctic environments and communities.

   ii) The development of better interplay among port authorities of the Arctic States when evaluating whether vessels meet the technical and crew related requirements set forth in the Polar Code. This could be facilitated by creating a forum for local authorities, classification societies and insurers that would improve collaborations that improve risk evaluation for vessels trading and transiting in the Arctic.

4) **Managing the marine and coastal environments through an integrated framework**
To reconcile the multiple political management objectives of ocean and coastal zone management, integrated frameworks are needed. This level of integrated management has, however, not yet been achieved in most parts of the Arctic, and thus presents a clear challenge. To enable progress towards such a management format, actions should address the barriers. Actions should build on adaptive ecosystem-based approaches supported by a dedicated observation programme. This includes recognizing the essential role of the Arctic Ocean and its coastal seas in providing food security for Arctic Indigenous Peoples.
Indigenous People's role in the management of marine environment and coastal ecosystems are also essential for an operable and comprehensive framework. Among key steps should be

the analysis of existing Arctic ecosystem-based management approaches[16] and best practices to determine what is needed to expand across the region as a whole while maintaining respect for national sovereignty, resource management, rights safeguards and preservation of cultural heritage. In collaboration with Indigenous representative organisations, efforts should be made to produce an international framework for integrated management by 2025 with specific commitments from Arctic nations by 2030.

5) **Managing vulnerable habitats or threatened species through designation of Marine Protected Areas (MPAs)**
In light of the global loss of biodiversity, the Arctic may present one of the few larger marine areas in world where the environment is relatively intact, due to historically low levels of human exploitation. However, as climate changes the Arctic, the integrity of multiple marine and coastal ecosystems and their dynamics are likely to be altered, not least because human activities will increase as seasonal sea ice retreats. Similarly, pollution levels are potentially changing as currents and air mass trajectories shift, influencing transport of pollutants. To address this challenge, the designation of vulnerable habitats and protected areas are relevant protection measures, as suggested by the targets for the Convention on Biological Diversity after 2020.
In order to achieve progress in this area, we need to identify Arctic biodiversity hot spots and ecologically important areas for calving, migration, feeding, moulting or mating for threatened and vulnerable species or habitats to identify candidate Marine Protected Areas (MPAs).
Actions should further address the development of relevant protection responses by resource managers and should be supported and implemented by relevant stakeholders including local inhabitants and business. Examples could include the designation of 'last ice areas' as refuges for ice-obligate species, 'low noise areas' for marine mammals or restrictions on trawling for preservation of vulnerable benthic habitats.

6) **Managing the marine and coastal areas with responsive enforcement measures**
The societal outcomes of the Decade cannot be achieved by excellent science and effective management frameworks alone. Enforcement of environmental regulation is a key supporting measure, which in the Arctic is challenging due to the remoteness of many areas, lack of communication and observation opportunities. To advance progress related to these logistic challenges, new approaches to data acquisition and sharing are needed together with enhanced international collaboration. Focus should in particular be on approaches to reduce environmental crimes such as illegal pollution or Illegal, unreported and unregulated fishing, both in exclusive economic zones under national jurisdiction and in the high sea areas of the Central Arctic Ocean.

7) **Collaborating with key business stakeholders and governments to create an Arctic Specific Corporate Social Responsibility (CSR) program**
Sustainable development in the region will not be achieved without the systematic involvement of Arctic Indigenous peoples as rights holders, local communities, business stakeholders as well as the public sector. Sustainability can, however span many priorities covering both cultural, environmental and economic themes. Progress in this area could be promoted through the work of bodies such as the Arctic Council, Arctic Economic Council or various the United Nations

[16] Integrated Ecosystem Assessment: Barents (ICES 2019), the Arctic Council's approach to managing marine ecosystems (Logerwell and Skjoldal 2019), Indigenous/Federal collaborations in Canada to protect marine ecosystems (Government of Canada 2011), UNESCO's identification of globally significant ecosystems in the Arctic Ocean (Speer et al. 2017),

agencies including the United Nations Global Compact working group on Sustainable Business in the Arctic. Similarly, a dedicated transpolar 'Corporate Social Responsibility' (CSR) programme could be developed to address concerns that are specific to the Arctic region, Arctic Indigenous peoples and their communities, and its local communities. This could for example be developed within the United Nations Global Environment Facility, and draw on global development models related to the CSR, including the so-called 'ESG' (Environmental, Social, and Corporate Governance) approaches already implemented by many companies. Action in this arena would be particularly suited as a steppingstone for integrating sustainability goals within business management strategies in the Arctic.

From the Arctic Action Plan to Ocean Decade Actions

The development of the Arctic Action Plan succeeded through efforts of broad range of stakeholders (Annex and list contributors). But as a decadal process, the Action Plan will be most valuable as a document that is updated or evaluated in the context of new political, social, scientific and economic events over the next decade.

The transformation of the Arctic Action Plan into implementation will be described in a Road Map, which is the plan for the way forward after the launch of the Action Plan and its secure the relevance throughout the Decade. It will describe the basis required to implement the Action Plan and to create the appropriate enabling environment for translating the Action Plan into, co-designed Decade Actions at multiple levels from coordination, to research and policy initiatives.

In particular the Road Map will:

- provide the plan for transformation of the Action Plan into Decade Actions – such actions could take a number of forms including a regional programme or a series of thematic projects which could be attached to other Decade programmes. All Decade Actions would be submitted for Decade endorsement by their proponents via Calls for Decade Actions that will be regularly launched by the Decade Coordination Unit (DCU).
- identify mechanisms to monitor progress and to regularly review the document to ensure that the Action Plan remains a living document reflecting regional priorities throughout the Decade. In this sense the review processes of the Action Plan may be developed to align with the Decade Monitoring and Evaluation Framework that is being developed by the DCU and the timing of the review processes of the Decade Implementation Plan that are described in Section 3 of that document.
- define who does what and when and define next steps to establish and confirm regional governance, for example through the establishment and operationalisation of a multi-stakeholder regional Task Force. It shall ensure that the ownership to the Action Plan is systematically reconfirmed and sought strengthened among Arctic nations, Artic regional organizations, indigenous organizations and fora.
- highlight what could be the mandate of the Regional Task Force moving forward and specify the relationship between the regional Task Force, the regional and thematic Communities of Practice that are being established as part of the Global Stakeholder Forum, and relevant National Decade Committees
- identify how the Task Force could play an ongoing role in facilitating the development and submission of co-designed programmes, projects, and initiatives for endorsement as official Decade activities as well as continue to foster multisector engagement
- identify expected and potential funding avenues for implementation of programmes, projects and initiatives building on the Action Plan and for regional coordination for example through mobilization of resources for the establishment of a regional Decade Collaborative Centre or Decade Coordination Office.
- identify stakeholder engagement and outreach activities to continue to engage regional stakeholders outside the Task Force and raise awareness of the Decade. This part of the roadmap may include specific mechanisms to engage priority groups including indigenous and local knowledge holders, Early Career Ocean Professionals, business and industry or philanthropy.

Expected Road Map elements:

1. Mapping of Action Plan to potential Decade Actions
2. Governance of the Arctic Action Plan
   a. Terms of Reference of the Task Force 2021-2030
   b. Coordination with Communities of Practice and National Decade Committees
3. Stakeholder Engagement and Outreach
4. Indigenous Engagement
5. Resource Mobilization
6. Monitoring of progress and process for periodic updating of the Arctic Action Plan in the form of an annual appendix or yearbook summary

Proposed way forward to confirm and establish the governance

As a broad United Nations-led initiative to harness scientific progress, including appropriate incorporation of Indigenous knowledge, for the purposes of promoting sustainable development, no one entity is likely to be able to address all of the potential needs for using the Action Plan as an instrument for addressing science-based sustainable development needs for the Arctic. However, a number of existing science coordination and planning organizations could be leveraged and help with implementing and adapting the Plan as the Ocean Decade proceeds.

For example, the Marine Working Group (MWG) of the International Arctic Science Committee (IASC) has members appointed by all 23 member countries of IASC and the MWG, as all working groups within IASC, has terms of reference that include supporting science-led international programs through planning and coordination, identifying where interdisciplinary actions would be advantageous, exchanging and disseminating information, ensuring interaction with other relevant international, regional and national arctic science organizations, and providing scientific advice to outside organizations upon request. Likewise, the Sustaining Arctic Observing Networks (SAON) activity, jointly supported by IASC and the Arctic Council through its Arctic Monitoring and Assessment Programme, provides a vehicle for connecting and networking with the Arctic states and the Permanent Observers participating in Arctic Council activities. These activities include efficiently addressing data storage with free and fair availability to that data, networking among existing Arctic observational systems, building capacity for expansion, and ensuring a growing and sustainable future for Arctic observations that meet societal needs.

Both SAON and the IASC-MWG have indicated an interest in assisting with updating of the Action Plan as needed over the course of the Decade and beyond. However, there is a clear recognition that the participation of other entities and programmes will be needed so that all parts of the Arctic Action Plan remain relevant to the societal goals set forth in this document and use scientific and Indigenous knowledge to promote sustainable development of the Arctic Ocean. Other stakeholder groups that represent users of ocean science or resource providers for ocean science including business and industry or philanthropy will be important actors in the implementation, monitoring and review of the Action Plan.

The process to onwards define the Road Map

1. Terms of Reference for an IASC led Task Force drafted in consultation between the initial Task Force, IASC and the Decade Coordination Unit.
2. Formalization of institutional rooting of an Arctic Task Force within IASC with involvement of multi-stakeholders as required.
3. Membership of an IASC led Arctic Task Force defined in a consultation among IASC and the Decade Secretariat.
4. Rejuvenated IASC led Task Force develops draft Road Map.
5. Draft Road Map will be circulated in the broad Arctic community and then revised at a dedicated on-line Task Force meeting.

LIST OF CONTRIBUTORS TO THE OCEAN DECADE ARCTIC PROCESS

Photo: Leif Bolding

Host

Following the Tromsø workshop, the Arctic process was facilitated by Prof. Colin Stedmon and research coordinator Christian Riisager-Simonsen from the secretariat of the Danish Centre for Marine Research located at the Technical University of Denmark. The final document was drafted by the hosts with support from the Task Force, Work Group chairs and feedback from an open global consultation on an advanced draft.

Task Force

The process was supported by the Arctic Task Force consisting of:

AMAP/SAON (Arctic Monitoring and Assessment Programme/Sustaining Arctic Observing Networks). Represented by Jan Rene Larsen / Craig Lee

ArcticNet (Canadian Network of Centres of Excellence). Represented by Jackie Dawson

AOOS (Alaska Ocean Observing System). Represented by Molly McCammon

APECS (Association of Polar Early Career Scientists). Represented by Anna Gebruk

DCMR (Danish Centre for Marine Research) who organized and lead the Action Plan development process. Represented by Colin Stedmon, Steffen Olsen, Karen Edelvang and Christian Riisager-Simonsen

IASC (International Arctic Science Committee). Represented by Lee Cooper

ICES (International Council for the Exploration of the Sea) represented by Julie Kellner

IMO (International Maritime Organization). Represented by Sascha Pristrom Goal-based-Standards (GBS) Implementation Officer in the Maritime Safety Division, and Loukas Kontogiannis head of Marine Pollution in the Marine Environment Protection Division

IOC UNESCO, who plans the Ocean Decade. Represented by Henrik Enevoldsen and Marie-Elaine Boivin

Kawerak Marine Program, who works on better inclusion of Indigenous priorities. Represented by Austin Ahmasuk and Adelaine M. Ahmasuk

Research Council of Norway, who organized the preparatory "Arctic Ocean Decade Policy-Business-Science-Dialogue" in Troms January 2020. Represented by Jon L. Fuglestad

Working group chairs and support

The working groups who were active in the autumn and winter 2021, was each chaired by two people and supported by a group of early-career researchers (ECR), who was recruited by the Association of Polar Early Career Scientists (APECS)

Working group 1:

Chairs:
- Colin Moffat – Scottish Government (UK)
- Toril Inga Røe Utvik - Equinor (Norway)

ECR's:
- Anna Gebruk
- Tamara Narganes Homfeldt

Working group 2:

Chairs:
- Brendan Kelly - University of Alaska Fairbanks (USA)
- Katherine Richardson - University of Copenhagen (Denmark)

ECR's:
- Tom Grove
- Moustapha Moussa
- Chloe Nunn

Working group 3:

Chairs:
- Anne Christine Brusendorff - ICES (International)
- Henry Huntington – The Ocean Conservancy (USA)

ECR's:
- Alisa Ilinskaya
- Malene Eilersen
- Susse Wegeberg
- Kjetil Gjeitsund Thorvaldsen

Working group 4:

Chairs:
- Sandy Starkweather - NOAA (USA)
- Mark Payne – Technical University of Denmark (Denmark)

ECR's:
- Holly Elizabeth Jenkins
- Jessica Newman
- Susana Hancock
- Alexander Kokorin

Working group 5:

Chairs:
- Matthew Owen – Geological Survey of Denmark and Greenland (Denmark)
- Lena Holm Saxtoft - SKULD (Denmark)

ECR's:
- Robert Taylor
- Patrizi Isabelle Duda

Working group 6:

Chairs:

- Nicole Biebow – Alfred Wegener Institute (Germany)
- Molly McCammon – Alaska Ocean Observing System (USA)

ECR's:

- Rachel Downey

Working group 7:

Chairs:

- Raychelle Danielle – Pew trust (USA)
- Gunn-Britt Retter – Saami Council (Norway)

ECR's:

- Hannah Griest

Affiliations of individuals participating in the work groups and consultation process

The process included a large diversity of stakeholders and people, of which many participated in their own capacity. The list of institutions and organizations therefore only imply that people from the organizations participated, not that the institutions them self necessarily provided specific comments, nor endorse the final document.

Institutions and organisations (alphabetical order)	**Country**
Murdoch University	Australia
Commonwealth Scientific Industrial Research Organisation (CSIRO)	Australia
Western Sydney University	Australia
Chittagong University	Bangladesh
Anguniaqvia niqiqyuam MPA Working group	Canada
Arctic Indigenous Wellness Foundation, Yellowknife Northwest Territories	Canada
Canadian Coast Guard	Canada
Canadian Fisheries Joint Management	Canada
Canadian Geodetic Survey (Natural Resources Canada)	Canada
Canadian Hydrographic Service	Canada
Canadian Ocean Literacy Coalition	Canada
Canadian Wildlife Service - Environment and Climate Change	Canada
(Government of Canada)	Canada

Dalhousie University Canada Department of National Defence	Canada
DRDC Atlantic Research Centre	Canada
Environment and Climate Change Canada	Canada
Fisheries and Oceans Canada	Canada
Fisheries Joint Management Committee	Canada
Geological Survey of Canada	Canada
Inuvialuit Regional Corporation	Canada
JASCO Applied Sciences	Canada
Joint Secretariat Inuvialuit Settlement Region	Canada
Laval University, Faculty of Medicine	Canada
MaritimeInnovation - Maritime Institute of Quebec (IMQ)	Canada
National Research Council Canada	Canada
NunatuKavut Community Council	Canada
Students on Ice Foundation	Canada
Tarium Niryutait MPA Working group	Canada
Transport Canada	Canada
University of British Columbia	Canada
University of Calgary	Canada
University of Manitoba	Canada
University of Toronto	Canada
Western Economic Diversification Canada	Canada
www.h2i.ca	Canada
Yukon Conservation Society	Canada
University of Santiago de Compostela	Chilie
Aalborg University	Denmark
Aarhus University	Denmark
Berring Data Collective	Denmark
Danish Geodata Agency	Denmark
Danish Joint Arctic Command	Denmark
Danish Meteorological Institute	Denmark

Danish Ministry of Defence Acquisition and Logistics Organisation, Joint GEOMETOC Support Centre	Denmark
Geological Survey of Denmark and Greenland	Denmark
Litehauz	Denmark
NIRAS A/S	Denmark
NIVA Danmark	Denmark
Survey Association of 1914 A/S	Denmark
Technical University of Denmark	Denmark
University of Copenhagen	Denmark
University of Southern Denmark	Denmark
Alexandria University	Egypt
KFS University	Egypt
National Institute of Oceanography and Fisheries	Egypt
Faroe Marine Research Institute (Havstovan)	Faroe Islands
Fiskaaling A/S	Faroe Islands
Jardfeingi	Faroe Islands
Sjókovin (Blue Resource)	Faroe Islands
University of the Faroe Islands	Faroe Islands
Vørn (MRCC Tórshavn)	Faroe Islands
University of the South Pacific	Fiji
University of Lapland, Arctic Centre	Finland
University of the Arctic - UArctic	Finland
HEIP	France
IFREMER	France
Tara ocean foundation	France
University of Strasbourg (Science Po Strasbourg)	France
AFRD Georgia	Georgia
Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research	Germany
Brandenburg University of technology, Cottbus-Senftenberg,	Germany
GEOMAR Helmholtz Center for Ocean Research Kiel	Germany

German Development Institute / Deutsches Institut für Entwicklungspolitik (DIE)	Germany
GIZ	Germany
Project Management Juelich	Germany
University of Hamburg	Germany
Tiwah UG	Germany
University of Piraeus, Dept. of Informatics	Greece
Greenland Institute of Natural Resources	Greenland
Agricultural University of Iceland	Iceland
Isbm	India
Mohanlal Sukhadia University Udaipur	India
Pondicherry university	India
Rajiv Gandhi School of Intellectual Property Law, Indian Institute of Technology, Kharagpur	India
Arctic Regional Ocean Observing System (ArcticROOS)	International
European Commission Directorate-General for Maritime Affairs and Fisheries	International
European Global Ocean Observing System (EuroGOOS)	International
European Polar Board	International
GESAMP	International
ICES (International Council for the Exploration of the Sea)	International
Inuit Circumpolar Council	International
JCOMMOPS/IOC	International
Marine Stewardship Council Baltic and Scandinavia	International
RedLAtM / YESS Community	International
UNEP MGCY	International
United Nations Institute for Training and Research	International
Consiglio Nazionale delle Ricerche (CNR)	Italy
Italian Hydrographic Office	Italy
National Institute of Oceanography and Applied Geophysics - OGS, Italy	Italy
Institute of Polar Sciences	Japan

Japan Aerospace Exploration Agency	Japan
Japan Agency for Marine Earth Science and Technology	Japan
National Institute of Polar Science	Japan
Tokyo university of marine science and technology	Japan
Kenya Marine and Fisheries Research Institute (KMFRI)	Kenya
Kids for Planet Earth Kenya	Kenya
Technical University of Mombasa	Kenya
Klaipėda University, Marine Research Institute	Lithuanian
Instituto Tecnológico y de Estudios Superiores de Monterrey (ITESM)	Mexico
Fugro	Netherlands
Akvaplan-NIVA	Norway
Arctic Consult	Norway
Arctic University of Norway (UiT)	Norway
Association of Arctic Expedition Cruise Operators (AECO)	Norway
Centre for the Ocean and the Arctic	Norway
Equinor ASA	Norway
GRID-Arenda, on behalf of UNEP	Norway
Hafenstrom	Norway
Henie Onstad Kunstsenter	Norway
Innovation Norway, India	Norway
Institute of Marine Research, Bergen	Norway
Meteorological Institute Norway	Norway
Nansen Environmental and Remote Sensing Center	Norway
Norges Miljø og Biovitenskapelige Universitet	Norway
Norwegian Institute for Water Research	Norway
Norwegian Institute of International Affairs (NUPI) and Nord University	Norway
Norwegian Meteorological Institute	Norway
Norwegian University of Life Sciences	Norway
Oslo Metropolitan University	Norway
Research Council of Norway	Norway

SNF - Centre for Applied Research at NHH	Norway
The Norwegian Coastal Administration	Norway
Universitetet i Oslo	Norway
University of Bergen	Norway
MSU-IIT	Philippines
University of the Philippines	Philippines
Aborigen Forum	Russia
All-Russia Research Institute of Hydrometeorological Information, World Data Centre	Russia
Arctic and Antarctic Research Institute	Russia
Far Eastern Regional Hydrometeorological Resarch Institute, Vladivostok	Russia
Federal Research Center of Computer Science and Control, Russian Academy of Sciences, Moscow	Russia
FSBI FERHRI	Russia
Lomonosov Moscow State University	Russia
N.N.Zubov's State Oceanographic Institute	Russia
NRC "Kurchatov Institute"	Russia
P.P. Shirshov Institute of Oceanology, Russian Academy of Sciences	Russia
Pacific Oceanological Institue, far East branch, Russian Academy of Sciences	Russia
Russian Federal Institute of Fisheries and Oceanography	Russia
Russian State Hydrometeorological University	Russia
Sami Heritage and Development Foundation	Russia
Shirshov Institute of Oceanology, Russian Academy of Sciences, Moscow	Russia
State Oceanographic Institute, Moscow	Russia
State Research Centre	Russia
Subtropical Scientific Centre of the Russian Academy of Sciences	Russia
The Russian Federal Service for Hydrometeorology and Environmental Monitoring (Roshydromet)	Russia
Marine Scotland, Scottish Government	Scotland
University of South Africa	South Africa
Swedish Metrological and Hydrological Institute	Sweden

Swedish Polar Research Secretariat	Sweden
World Maritime University	Sweden
National Chengchi University	Taiwan
University of Dodoma	Tanzania
Asian Maritime Technological College	Thailand
Anglia Ruskin University	UK
British Antarctic Survey	UK
Cefas (Centre for Environment, Fisheries, and Aquaculture Science)	UK
Marine Stewardship Council	UK
National Oceanography Centre	UK
Plymouth Marine Laboratory	UK
Red Penguin Marine	UK
SafetyNet Technologies	UK
UK Natural Environment Research Council Arctic Office	UK
University of Exeter	UK
University of Gloucestershire	UK
University of Portsmouth	UK
Whale and Dolphin Conservation Society	UK
Academy for Mathematics, Science, and Engineering	USA
Alaska Fisheries Science Center, NOAA Fisheries	USA
Applied Research in Environmental Sciences Nonprofit, Inc.	USA
Association for Village Council Presidents	USA
Baeseman Consulting & Services	USA
Baker Arctic Consulting/ Wilson Center Polar Institute	USA
Blue Institute Labs	USA
e360 LLC, iCatalysts	USA
Exocetus Autonomous Systems	USA
ExperTech	USA
George Mason University	USA
Harvard Law School	USA

Journey Partners	USA
Los Alamos National Laboratory	USA
Maritime Enforcement Operations Center	USA
National Oceanic & Atmospheric Administration (NOAA)	USA
North Pacific Research Board	USA
Old Dominion University	USA
Pacific Environment	USA
PolArctic	USA
Scripps Institution of Oceanography	USA
Sonalysts	USA
The Arctic Institute	USA
The Citadel Military College of South Carolina	USA
The Lawrence Law Firm, PA	USA
The Pew Charitable Trusts	USA
U.S. Committee on the Marine Transportation System	USA
U.S. Department of the Interior	USA
U.S. National Oceanic & Atmospheric Administration National Marine Fisheries Service	USA
Univ. of Colorado, Boulder/CIRES/National Snow and Ice Data Center	USA
University of Alaska Fairbanks	USA
University of Alaska Southeast	USA
University of Maine	USA
University of Maryland Center for Environmental Science	USA
University of Northern Iowa	USA
University of Washington	USA
US Coast Guard Pacific Area	USA
Wilson Center Polar Institute	USA
World Ocean Council	USA

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Danish Center for Marine Research

United Nations Educational, Scientific and Cultural Organization

Intergovernmental Oceanographic Commission

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