Integrated Arctic Observation System

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Report on stakeholder interaction in year 2 and 3

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PU	Public, fully open	X
CO	Confidential, restricted under conditions set out in Model Grant Agreement	
CI	Classified, information as referred to in Commission Decision 2001/844/EC	

EXECUTIVE SUMMARY

An overview of information, products and services requested by users representing primarily the private commercial sector has been collected via INTAROS user survey supplemented with results from similar surveys performed by other projects and organisations together with information obtained by INTAROS consortium members in dialog with relevant user at meetings, workshops and conferences.

Most important products:

- Pre-operational phase
  - Model projections on the long-term (years) development
  - Risk assessment associated with safe navigation, deployment and recovery of gear, seabed mining, hydrocarbon extraction etc
  - Statistics and analysis based on existing data
- Operational Phase
  - Operational Services – real-time observations and/or short-term forecasts (5-10 days)
  - Ship routing
  - Risk assessment

Information on sea Ice (concentration, ice edge, drift thickness) and iceberg are central in the required product portfolio; but the surveys additionally revealed requests for meteorological parameters (pressure, wind, temperature, visibility, precipitation, humidity, icing) and oceanographic parameters (temperature, currents and waves, salinity, oxygen and chlorophyll).

The users have very strong demands to resolution in space and time, quality and timeliness of the products they receive:

- a horizontal resolution of down to 100 m especially for special ice products was articulated.
- Updating frequency for the information are generally requested to be less than one day preferably down to a few hours.
- Quality shall regularly be documented and the inclusion of uncertainty information as an integral part of the product is desirable
- For operational services it is important that every product update is available in near real-time. For other types of products up to a few days are regarded as timely delivery.
- For model forecast the most important forecasting period is the next 2-3 days for operational purposes, while longer forecasting periods 7-10 days are valuable for more long-term planning purposes.

Due to the limited communication facilities in the Arctic region the delivery of the requested products represents a special challenge.

This overview is a valuable tool for service providers to plan the production line. The required resolution in time and space indicates that satellite observations and model simulations will be key components in the product generation. In situ observations are however indispensable for such a production line to secure the quality of products generated based on satellite observations and numerical models, but do also serve as a valuable source of information for product generation in itself.

The design and establishment of a fit-for-purpose sustained Arctic Observation System is therefore of outmost importance.

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1. Introduction

The overall objective of INTAROS is to build an efficient integrated Arctic Observation System (iAOS) by extending, improving and unifying existing systems in the different regions of the Arctic.

It is envisioned that an integrated Arctic Observing System will provide essential data and knowledge of Arctic environmental processes to underpin a knowledge-driven society that can advance the Arctic economy whilst ensuring environmental sustainability. Successful delivery of products for societal benefit critically depends on interactions between many centres of competence operating across the boundaries between knowledge, society and policy. Societal requirements for timely and adaptive policy responses on, for example, climate mitigation and adaptation, ecosystem health and operational services, will be based on an efficient transfer of information which occurs through two branches of the observing system value chain:

1. Scientific advisory and assessment,
2. O3$perational services delivery.

Both branches of this service value chain will rely on sustained in situ observations delivering against requirements of Essential Variables. These requirements will have been reconciled with the end user needs for a variety of Arctic applications.

To meet the user needs, the system must, therefore, ensure an uninterrupted execution of the service value chain by the elimination of all critical gaps in observing capacity, technology, data availability and sustainability. The integrated Arctic Observing System must therefore be capable of adapting its multi-platform design according to the changing user needs, funding opportunities, and technological advances, ensuring a comprehensive and concerted observing of the Arctic physical, biogeochemical and biological state and evolution, that can provide rapid access to reliable and accurate information, freely and openly available for end-user exploitation.

User needs evolve with changing citizens' concerns, public policies, industry priorities, and Arctic states, as well as technological improvements which enhances the feasibility of new measurements. Thus, individual components of the service value chain (e.g., networks, data managers, application developers) and integrators across the components must constantly work with end-users to refine high-level requirements and to optimise the information, delivery methods, and observing technologies to ensure that the clients are receiving quality timely information in a form that they can use.

An important first step in the design of an integrated Arctic Observing System therefore is to identify key users and user groups to establish a dialog on their need for information, products and services. It is mandatory that this consultation process is repeated on a regular basis to allow service providers to adjust their production line, which also includes requirements for in situ data.

An integral part of the INTAROS project is to perform user/stakeholder consultations consisting on several activities and levels:

- Task 1.2 is devoted to organise three stakeholder workshops.
- The individual tasks in WP6 will organise dedicated user consultations
- Dialog with users during conferences, meetings, workshops, teleconferences etc.

The first Task 1.2 stakeholder meeting took place in the early phase of the project (5 May 2017) and was attended by 30 invited representatives from the scientific community. Focus was to review the INTAROS Initial Requirement Report (D1.1).

The second Task 1.2 stakeholder consultation has been decided to focus on private commercial sector including representatives from shipping, oil/gas, fishing industry, aquaculture and recreation, which also is the focus user group for Task 6.3, so the consultation is a joint effort. Since the private commercial sector is so diverse and often very busy, it was decided not to organise a "physical" meeting, but instead rely on a web-based survey supplemented with relevant information retrieved from similar user consultations and INTAROS partners participation conferences, meetings and workshop.

The present report represents the outcome of the second INTAROS stakeholder consultations and summarises information of user requirements for information, products and services collected via:

1. INTAROS questionnaire
2. Results from relevant EU-funded projects with Arctic focus (members of the EU ARCTIC Cluster)
3. Requirements collected via INTAROS representatives' dialog with users at conferences, meetings and workshops.

2. Stakeholder consultation work

The INTAROS project and its partners has during the recent two years had several contacts to stakeholders to collect as detailed as possible information on their requirements for products and services to optimise their operations in the Arctic incl. increase safety.

2.1 INTAROS user survey

According to the INTAROS workplan the second stakeholder consultation to be organised by Task 1.2 was scheduled to be carried out halfway into the project (medio 2019). Additionally, the work in WP6 "Applications of iAOS towards Stakeholders" has just been initiated and include several initiatives towards dialog with selected stakeholder communities. On this background it was decided in the INTAROS Steering Group that the second stakeholder consultation should focus on collecting information on the private industry sectors need for information, products and services.

When planning the consultation in detail two approaches was discussed:

1. Organise a workshop with invited representatives from different branches operating in the Arctic
2. Conduct a questionnaire survey distributed to broader group of stakeholders from the private industry

Option 2 was chosen hoping that it would provide an input from more stakeholders than a workshop could attract and that it would be possible to collect more detailed information's on user requirements.

A web-based questionnaire was constructed (see Appendix 1), it consisted of 5 parts:

1. General information
2. Pre-operational phase – which products and services is needed by an organisation considering and preparing for entering into operational activities in the Arctic region
3. Operational phase - which products and services is needed by an organisation active in the Arctic region
4. Requirements to products and services
5. Preferred delivery of products and services

An invitation to reply was send to representatives from companies active or preparing for activities in the Arctic region representing sectors such as transportation, oil, gas and minerals, tourism, fishery, wind energy, insurance and coast guard (safety) as well as interest organisations representing these business sectors – in total around 75 persons was invited.

Only six relies was received at the time of the reply deadline (medio October), therefore a reminder was sent to all invitees announcing an extension of the reply deadline to 1. November 2019. This, however only resulted in one additional reply; so very disappointing only 7 replies were received.

The limited number of replies received in the performed stakeholder consultation do not allow for a detailed analysis and conclusions, but some relevant information can be subtracted from the relies and will be presented in the following, because combined with results from similar survey performed by other projects and information collected within the INTAROS project via stakeholder contacts at conferences, meetings and workshops , it may be possible to draw some conclusions on user requirements for information, products and services in the Arctic region. Details on the replies to the INTAOS questionnaire are presented in Appendix 2.

Respondents represent maritime transport, oil industry, tourism and coastguard/Rescue Coordination Centre.

Pre-operational phase

Four respondents expressed interest in preoperational services. Most required services are:

- risk assessment and model projections (years) of future development in environmental conditions (75%)
- statistics and analysis based on existing data (50%)
- Data for analysis and environmental impact assessment (25%)

For each of the required products the respondents were asked to indicate which parameters within meteorology, oceanography and sea ice incl. icebergs they were interested in getting data on.

Requested parameters:

- Sea ice parameters
  - concentration, drift, ice edge, thickness and icebergs had high priority
  - Ice type had low to medium priority
- Meteorological parameters
  - air pressure, humidity, icing, precipitation, temperature, visibility and wind all had had priority.
- Oceanographic parameters
  - temperature, currents and waves had high priority
  - salinity, oxygen and bathymetry had medium priority
  - chlorophyll had low priority
  - nutrient was not requested

Articulated special requirements:

- Charting for navigation
- Risk assessment
  - Risks associated with the safe deployment and recovery of marine autonomous systems in polar waters, in all weather conditions and seasons. Also risks associated with hydrocarbon extraction, seabed mining and use of new propulsion technologies
  - For aircraft and ships operating in the area
  - Model for safe navigation, based on all meteorological, ice and bathymetric charting data.
- Environmental Impact Assessment
  - Data pertaining to prediction of spread of oil spills, radiation leaks and seabed mining plumes.
- Other products and services
  - Improvements to ice charts (including weekend charts in Svalbard) and improvements/expanding navigational charts

Operational phase

Five respondents expressed interest in preoperational services. Most required services are:

- Operational services – near real-time observations and/or short term (5-10 days) forecasts and ship routing service (100%)
- Risk assessment (80%)
- Data for analysis (40%)
- Environmental assessment and stock assessment (20%)

Requested parameters:

- Sea ice parameters

- o concentration, drift, ice edge, thickness and icebergs had high priority
- o Ice type had low to medium priority
- Meteorological parameters
  - icing, temperature and wind had high priority
  - Air pressure, visibility, humidity, precipitation had medium priority
- Oceanographic parameters
  - temperature, currents and waves had high priority
  - salinity and bathymetry had medium-low priority
  - Oxygen and chlorophyll had low priority
  - nutrient was not requested

Articulated special requirements:

- ship routing service (4 responses)
  - Ice, waves, icing
  - main shipping routes used by merchant and passenger vessels; areas used by pleasure boats
  - VTS (Vessel Traffic System)
  - wind, wave, pressure, all ice information's
- Risk assessment (2 responses)
  - specific tools to analyse vessel traffic in the area
  - Needed for safe navigation
- Environmental impact assessment
  - How weather, ice and sea current affect the ability to operate

Requirement to products and services

Six respondents

Resolution in space: user has high demand for spatial resolution – 2/3 requested 100 m

Resolution in time: 2/3 wished a resolution of 1 hour or less; 12 hours was the highest acceptable time step.

Timeliness: real-time service was the most requested service and 1 week delay the most acceptable delay

Quality: majority requested products to include uncertainty information while the remaining respondents requested regular quality documentation.

Delivery format: web-based in agreed format and e-mail are the preferred formats followed by datafiles in format suited for own presentation and reports while text bulletins and supplementary personal briefing had the lowest score.

The user requirements collected by the INTAROS survey is unfortunately too limited to draw any strong conclusion on but from a planning perspective it is however important to notice that users articulate requests for information on the basic parameters within meteorology, oceanography and sea ice, which means that a future implementation of an Arctic Observing System include platforms for monitoring all three spheres in a space and time resolution, quality and timelines appropriate to support the production of the requested information, products and services.

2.2 INTAROS information collected at various meetings

INTAROS partners have had opportunities to meet stakeholder representatives at workshops, meetings and conferences – some organised by INTAROS; others with INTAROS representation.

2.2.1 Workshops and dialog with the local community in Longyearbyen

A workshop and dialogue meeting with local community members took place in Longyearbyen, at the University Center (UNIS) on December 6, 2018, 24 participants from the business sector, tourism, local council, research, University Center, Safety Center and the Governor's office took part in a workshop that was part of the INTAROS WP4 on Community-based monitoring. The workshop was arranged by INTAROS, by Finn Danielsen (NORDECO), Lisbeth Iversen (NERSC) and MIchael Køie Poulsen (NORDECO).

The focus was, through dialogue between key actors, to discuss opportunities for a better use of "citizen science" and community-based monitoring for sustainable development in Svalbard, and to make socially relevant information available, and ensure the best possible development of the community, business and tourism. The discussions were mainly for local stakeholders from Svalbard. Some of the participants were new compared to the previous day, when INTAROS WP4 hosted a workshop together with Arctic Cruise Operators, AECO.

The central question raised in the workshop was: "How can we contribute to sustainable management and development in Svalbard and in the region?"

Through group work and discussions in plenum, the participants looked at opportunities and needs across sectors and actors. The leader of the Planning and Development Department in the local council, presented key issues addressed by the local council; local democracy, work and business in Longyearbyen, nature and environment, and the changing climate. Sustainable planning and urban development in the Arctic, to provide a safe and attractive place for the community are challenging tasks. Public services, infrastructure and logistics – inc. energy production, the field of culture and leisure, with access to nature, a rich cultural life and sports, are all important parts of the efforts to provide good living conditions for the inhabitants. Longyearbyen Local Council as an organization was also presented. The main issue for the local council in 2017-2019 is planning for new safe homes and plans to secure or demolish 140 homes, as well as the development of better school service, and development for tourism and business in general.

The local Business Association in Svalbard, could not recall any collaboration between researchers and local businesses. Five years ago, Longyearbyen was a thriving town based on mining, with minor tourist activities and a stable Norwegian community, according to the business association. The community became more unstable in 2015, and a decision was taken to develop the tourist sector. This has resulted in an increasing number of non-Norwegians at Svalbard. The number of non-Norwegians in schools and kindergartens has increased to 50%, and the turnover is rather high. Research is needed to monitor and understand the changing local society.

The participants discussed how the environment in the Arctic region is changing fast. Better environmental monitoring and management is urgently needed. The changes in the environment are due to increasing temperatures. Sea ice is decreasing, human activities are increasing and wildlife is affected. These changes have a severe impact on people's living conditions in Longyearbyen and Svalbard. To ensure sustainable development in the Arctic, more knowledge is needed on climate and environment.

The leader of UNIS Safety Center talked about the objective of the Arctic Safety Center that was established to contribute to a safe and sustainable human presence in the high Arctic. The ambition is that the centre should share knowledge and build competence though education and research, tailor-made courses and guidance to academia, industry and Arctic settlements.

They undertake research and sell safety training to the industry, as well as to the cruise operators. Collaboration between different stakeholders is established through *the Svalbard Portal***,** which is aimed at being an e-learning platform that provides up-to-date knowledge on the natural environment in Svalbard, and information on how we can have a safe presence in the natural environment. It is funded by the Svalbard Environmental Protection Fund. The partners behind the portal are Longyearbyen Local Council,

The Governor, Visit Svalbard and The Norwegian Polar Institute.
Another example of collaboration is the *Driva Project,* where snow sensors are deplied in the terrain to obtain data for practical use. The information provided by the stations can help provide a better and more fact-based picture of snow drift and avalanches in selected areas. It is not a citizen science project, but this information, in combination with avalanche warnings and other observations, will help to provide a better basis for decisions relating to activities and visits in the terrain.

BaseCamp Explorer Foundation, representing a part of the tourist activities, is operating through what they call *sustainable tourism*. They shared information from their work in the field of “Travel and Adventure”, and opportunities for collaboration and shared knowledge, important to this field. The Foundation helps with strategic fundraising for relevant projects in the region, in which they are running their tourism business. They always seek a broader approach that also invites their guests, partners in tourism and institutions to join in.

Through group and plenum discussions, the participants looked more specifically at opportunities and needs across sectors and actors, today and in the future. It was suggested to arrange a social science side event at the Svalbard Science Conference, to present what was discussed at this workshop. This was arranged by the newly established Svalbard Social Science Initiative, SSSI (https://www.svalbardsocialscience.com/) on November 4 2019 in Oslo, supported by the Svalbard Science Forum and Nansen Environmental and Remote Sensing Center .

The workshop participants also proposed to use the field staff from the Governor’s office to gather further information, share data, ask for more detailed data, photos, etc. The establishment of tighter criteria on what constitutes a research cruise should be addressed. Stronger cooperation with all local industries/businesses and local authorities involved should be emphasised, as well as support to the cruise industry to give better information to tourists and local communities on environmental, social and cultural matters.

Better infrastructure in the local communities, such as walking paths and pavements for resident safety, should be provided both for the locals and visiting tourists. Further knowledge to provide updated local information on environmental protection, suggested routes, safety "suggestions" for 2, 3, 5 and 10-hour stay, must be presented.

Ideas were raised about more local power to impose restrictions on the tour operators, by the requirement of compulsory AECO membership or maximum numbers of tourists. For monitoring, there may be need for further vessel tracking, and the monitoring of visitor numbers. There is also a need for more knowledge-based arguments for business development, and more research on the limitations and possibilities for development and business, and likewise on the values of tourists coming to Svalbard. Many come to experience the emptiness and pristine untouched nature, but overcrowding will damage the environment and have negative impact on the local community.

The workshop report is available at:
https://intaros.nersc.no/sites/intaros.nersc.no/files/Report-from-workshop Longyerbyen Dec 6 2018-v5 0.pdf

2.2.2 Stakeholders at cruise expedition monitoring workshop in Svalbard

A cruise expedition monitoring workshop was held in Svalbard at the University Center (UNIS) on March 7, 2019 (https://intaros.nersc.no/content/cruise-expedition-monitoring-workshop). The workshop was part of the INTAROS WP4 on Community-based monitoring and was arranged by INTAROS and the Association of Expedition Cruise Operators (AECO). The workshop was organised by Finn Danielsen (NORDECO), Lisbeth Iversen (NERSC) and Michael Køie Poulsen (NORDECO).
The workshop had 18 participants from 6 countries and offered an opportunity for different stakeholders like cruise operators, citizen science programs, local government and scientists in the Arctic to come together to exchange experiences and perspectives.

The large expanse of the Arctic and the many remote parts that are rarely visited by scientists or anybody at all is a challenge for environmental monitoring. Cruise ships are regularly reaching otherwise rarely visited places. Tour guides and passengers can contribute meaningfully to environmental monitoring in the Arctic. Some cruise operators are already participating in environmental monitoring. It may be possible to learn from existing efforts, build on these and extend the participatory monitoring to even more cruises. Expedition cruises have the potential to support environmental protection efforts by obtaining information that can help scientists conduct conservation research and provide a better basis for management decisions.

The long-term objective is the better management of climate challenges, wildlife and cultural sites. Specific objectives include:

- Surveying and analysing existing community-based observing programs (including citizen science programs) in the Arctic in order to identify capabilities, best practices and challenges.
- Piloting community-based networks observing relevant parameters in Svalbard and Greenland, in order to support local and national decision-making processes.

Representatives from cruise operators, citizen science programs, local government, local scientists and INTAROS met to discuss and develop a Cruise Expeditions Monitoring Program. The main focus was on working towards agreeing on simple methods that can be used alongside the normal cruise activities at sea and on land, and which can be reported on, as far as possible, by using the same format. Such approaches can be meaningful to all involved and may make the cruises an even richer experience for both guides and guests.

The guests and guides will see the importance of their observations and will feel that they are making a contribution to the environment. The cruise operators will get a say when it comes to selecting appropriate management interventions that do not harm their operations unnecessarily. The researchers will obtain data and information, and decision-makers will be able to enter into a dialogue with cruise operators and obtain stronger evidence for management decisions. The monitoring may include observations from guides and guests, photographs, or the taking of water, ice or soil samples for later analysis by scientists, etc. The cruise operators will own the monitoring program and the resulting data but this will be shared widely as long as ownership is recognized. The receivers of the data, samples and reports may include cruise guests, cruise guides, relevant databases, conservation organizations and research institutions, as well as the authorities responsible for recommending or deciding on management actions.

The stakeholders asked for improved coordinated and more widespread environmental monitoring efforts on the part of cruise ships. A selection of different types of already existing citizen science programs were selected for testing during the 2019 Arctic season. There was a strong wish for intermediate organization connecting cruise expeditions with citizen science programs and facilitation smooth communication and feed-back.

The workshop report is available at
https://intaros.nersc.no/sites/intaros.nersc.no/files/Report-from-workshop-cruise-ships-v3.pdf

2.2.3 Dialogue with Norwegian Environment Agency

Norwegian Environment Agency is a governmental agency with responsibility for environmental and climate monitoring and therefore collection of data to support management and policy making. In the Arctic there is a great need for more data on the state and changes in the environment. There are ongoing monitoring programs for selected environmental parameters in the Barents Sea and Svalbard area, but most environmental data lack time series that last for a long time. In the Arctic Ocean there are practically no long-term measurements, only expedition-based data collection. Another challenge is that there is generally a lack of knowledge about data management in research environments. This means that a significant portion of the data collected is not facilitated for use outside the research communities. Thus, the usefulness of the data becomes worse than it should be for research, management and business. Several initiatives have been initiated, both nationally and internationally, with the aim of establishing and further developing arctic observation systems and data infrastructure in the fields of atmosphere, sea and terrestrial disciplines. These observation systems are largely based on data and monitoring from various data providers or owners. There are many players, including in Norway, each covering their thematic and/or geographical areas. In Norway, however, we do not have a comprehensive overview of what is contained in Norwegian data, where and how they are stored and made available. From a Norwegian perspective, it is important to support the development of arctic data management, initially through facilitating and contributing information about where there are Norwegian data and how these data can be made available.

Based in the survey and assessment of the observing systems performed in INTAROS, the Nansen Center is running a project with title "Marine data in the Arctic – from mapping to knowledge" with funding from Norwegian Environment Agency. The project develops an online tool that the Agency can use to follow up surveys of observation and data management systems and evaluate the usefulness of different types of marine data against user needs.

2.2.4 Dialogue with Norwegian Coast Guard and Norwegian Coastal Authority

An important part of INTAROS WP3 is to have access to ship time with ice-going vessels to deploy ice-buoys and underwater moorings in ice-covered areas in the Arctic. Research expeditions with the Norwegian Coast Guard icebreaker KV Svalbard were implemented in both 2018 and 2019 to support INTAROS WP3 in deployment and recovery of observing systems north of Svalbard. In the planning phase of these expeditions, NERSC had several meetings with the Norwegian Coast Guard and the Norwegian Coastal Authority in order to plan the expeditions in the best possible way. In the 2019 expedition, KV Svalbard reached all the way to the North Pole, where several ice buoys were deployed. The expedition was successfully completed thanks to good planning and outstanding support to ice navigation from satellite data providers, especially regarding Synthetic Aperture Radar images from Sentinel-1 delivered by the Norwegian Ice Service. The experience from this expedition was extremely valuable and will be used by the Norwegian Coast Guard as well as the Norwegian Coastal Authority in future Arctic expeditions. The increase in cruise expeditions to the Arctic in the coming years will require better information of sea ice conditions and better preparedness and response to ship emergencies, as described above. The Norwegian Coastal Authority has responsibility for search and rescue in the Norwegian sector of the Arctic.

2.2.5 Work with SAON Board to develop a Roadmap for SAON

INTAROS has been invited to and attended the SAON Board meeting during the Arctic Science Summit Week in 2017 (Prague), 2018 (Davos) and 2019 (Arkhangelsk). The SAON Board is particularly interested in the survey and assessment of various Arctic observing systems, which was led by Roberta Pirazzini, FMI. Such specific information about the performance of various systems is not available from other inventories which have been compiled earlier by other projects such as EU-Polarnet. The maturity score from 1 to 6 has been applied to a number of parameters, such as sustainability of the observing system, data management, metadata specification, uncertainty characterisation and others. The results give detailed insight into strengths and weaknesses of various observing systems, and what are the major bottlenecks in further development of the systems. Synthesis of the results of the surveys is presented in two reports: D2.10 and D2.11 (in prep)

Since April 2019 S. Sandven has been member of the SAON Road Map Task Force (RMTF), which has been tasked to develop the SAON *Road Map for Arctic Observing*. This Road Map is essential to generating strong national investments in coordinated international Arctic observing, through confidently and coherently presenting the imperative observing foci, a strategy for observing them that leverages existing efforts and interests, supported by a value assessment of observing outputs towards societal benefit. The SAON *Road Map for Arctic Observing* definition should build upon national efforts and needs, existing Arctic road mapping activities, and ultimately serve as a guide for developing concrete national plans to support pan-Arctic observing needs. At the Arctic Circle conference in Reykjavik in October 2019, the Roadmap for Arctic Observing and Data Systems (ROADS) was presented. The document is a high-level description of what SAON could do regarding coordination of observing activities across scientific disciplines. The ROADS document is an important background for the INTAROS Roadmap, which will be developed until the end of the contract in 2021. The INTAROS Roadmap will address the further development of the specific disciplinary observing systems, which need to build on the existing organisational, technological, logistically and financial solutions.

The SAON Board is very interested to be partner in the new H2020 call: *Supporting the implementation of GEOSS in the Arctic in collaboration with Copernicus*. This call is a direct follow-up of the ongoing work in INTAROS, namely to improve the in situ component of the Arctic observing system, advance the operationalisation of the systems, include local communities and indigenous peoples knowledge, develop pilot services and contribute to interoperability of Arctic Data systems.

2.2.6 Work with the Arctic Data Committee

The Arctic Data Committee (ADC) was set up by Inter Agency Standing Committee (IASC) and SAON to promote and facilitate international collaboration towards the goal of free, ethically open, sustained and timely access to Arctic data. The ADC has established expert groups to examine specific questions or coordinate the implementation of data management and sharing solutions. This is a very important task since the amount and complexity of Arctic data is growing year by year. ADC can thereby contribute to the understanding of the nature and structure of the Arctic data systems in the context of the global data system. ADC encourages partnerships with existing or proposed initiatives driven by members of the Arctic science and data community as well as Northern communities. The work of ADC is fully in line with the INTAROS objectives to develop integrated Arctic Observing systems. NERSC scientists (Torill Hamre, Frode Monsen, Hanne Sagen and Stein Sandven) contribute to the work of the Arctic Data Committee, in particular by participating in the planning and implementation the Fourth Polar Data Forum meeting at FMI in Helsinki in November 2019.

2.2.7 Dialogue with Arctic Council Working Groups AMAP, CAFF and EPPR

Arctic Monitoring and Assessment Programme (AMAP) is one of six working groups under the Arctic Council with mandate to monitor and assess the status of the Arctic region with respect to pollution and climate change issues. Since it started in 1991 AMAP has compiled data related to climate and pollution issues and produced a series of high-quality reports. AMAP has also established thematic data centres which compile data from relevant monitoring and research activities and make them available to scientists engaged in AMAP assessments. INTAROS is in dialogue with AMAP through Marianne Kroglund in Norwegian Environmental Agency, who is present chair of AMAP. Marianne Kroglund is also member of the Advisory Panel of INTAROS and can thereby give us direct recommendations about the needs from AMAP. The survey and assessment of Arctic observing systems performed in WP2 is of high interest for AMAP, because there is lack of good systems to monitor the increasing amount of observing activities in the Arctic. The Arctic Mapping project, led by NERSC, is a follow-up of the WP2 survey, where we will develop an online tool to monitor status of observing systems in the Arctic.

The Conservation of Arctic Flora and Fauna (CAFF) is another working group under Arctic Council. It is mandated to provide the most recent scientific information and data to Arctic policy makers through the Circumpolar Arctic Biodiversity Monitoring Programme (CBMP). INTAROS is in dialogue with Tom Barry and Tom Christensen in CBMP about collaboration on development of data systems for the Arctic. Biology and ecosystem data organized through the Arctic Biodiversity Data Service (ABDS) is very important because there no other systems providing this type of data. ABDS is the online, interoperable data management system for biodiversity data generated via CAFF. The goal of ABDS is to facilitate access, integration, analysis and display of biodiversity information for scientists, managers, policy makers and others working to understand, conserve and manage the Arctic's wildlife and ecosystems. ABDS aims to become more integrated and interoperable with other observing systems, and here we envisage that collaboration with INTAROS will be useful.

Emergency Prevention, Preparedness and Response (EPPR) is a third working group under Arctic Council, which is mandated to contribute to the prevention, preparedness and response to environmental and other emergencies, accidents, and Search and Rescue (SAR). EPPR is not operational response organization, but it conducts projects to address gaps, prepare strategies, share information, collect data, and collaborate with relevant partners on capabilities and research needs that exist in the Arctic. During Arctic Frontier, 2019, INTAROS had meeting with the chair of EPPR, Jens Peter Holst-Andersen, were we discussed how to better inform about and disseminate data that are of importance for the projects of EPPR. Development of Arctic safety requires better access to many types of data collected from different scientific fields, implying that EPPR is interested in developing interoperability between data repositories.

2.2.8 Information collected on WP6 stakeholder contacts

INTAROS has actively engaged with stakeholders local to or operating in Svalbard, particularly in Task 6.6. *Demonstrating the benefits of cross-fertilizing local and scientific observation systems,* led by Lisbeth Iversen (LE), NERSC. A policy brief for Longyearbyen, Svalbard, on topics of high priority to the local communities, using information from both local and scientific observation systems, and concerns of local actors, is an important output from this part of INTAROS. As part of the preparations, a workshop with local stakeholders and decision makers was held in Longyearbyen in March 2019. Here topics of high priority to the local community and the Governor's office were discussed. The dialogue with the local community/ key stakeholders has been further strengthened with INTAROS participation in a Local Council meeting on risk and precaution work and presenting and taking part in the Arctic Safety Conference, both in Longyearbyen in May. Key stakeholders include the office of the Governor of Svalbard, politicians, citizens, private sector representatives, expedition tour operators (AECO), and scientists, including youth. Further, LE chaired a side meeting on The Svalbard Social Science initiative at the Svalbard Science Conference in November 2019. Meeting participants included people from the local communities in Svalbard and researchers from the social sciences, arts and humanities studying the human dimension of living in Svalbard.

The project BarentsRISK (*Assessing risks of cumulative impacts on the Barents Sea ecosystem and its services*), funded by the Research Council of Norway has had two stakeholders' workshops focusing on the Barents Sea during autumn 2019. These are of high relevance to INTAROS and with participation by INTAROS WP6 leader Geir Ottersen and task 6.2 leader Gro van der Meeren, both IMR. The first workshop was on *the future Barents Sea, risks, mitigation and adaptation options* and included 10 stakeholders from respectively the Norwegian Radiation and Nuclear safety authority, the Norwegian petroleum directorate, the Norwegian environmental agency, the Norwegian coastal administration, the Norwegian Polar institute, ICES, Equinor, The Norwegian ocean-going fishers organization, Biotech North and WWF. The objective of the workshop was to undertake a joint exploration of the possible states of the Barents Sea by the horizon 2050, the associated risks and the possible ways to mitigate or adapt to them. The second workshop had a similar broad group of stakeholders and focused on cumulative impacts from different pressures on the Barents Sea. Working in small groups the stakeholders constructed conceptual models of how their sector/interest group see the interactions and risks. Future stakeholder workshops are scheduled for 2020, e.g., towards deliverable D6.10 (M54) *Report on ecosystem management* ecological model results from the Barents Sea and Disko Bay will be presented and discussed with fisheries and environmental managers at workshops respectively in Norway and on Greenland.

2.2.9 Workshops with Indigenous people in Alaska, Canada and Russia

2.2.1.1 Alaska

A workshop was held in Fairbanks, Alaska, May 10, 2017 (proceedings in Fidel et al. 2017). The workshop offered an opportunity for practitioners of community-based monitoring (CBM) and observing programs to come together to exchange experiences and perspectives. Representatives from 10 CBM programs from Alaska and Canada were in attendance. Additional participants included researchers and government officials currently involved in CBM. The workshop was held at the

University of Alaska's International Arctic Research Center (IARC) as part of the Week of the Arctic activities that concluded the U.S. Arctic Council Chairmanship. Representatives from the Arctic Council working groups, Alaska and US agencies, and the public were invited to a two-hour dialogue immediately following the workshop focusing on the use of CBM in decision-making and assessment.

The workshop concluded that there are many excellent CBM programs in Alaska and beyond. They are actively documenting observations of a wide range of phenomena. While much progress has been made in this field, additional coordination and investment is needed. This can facilitate the ability of CBM programs to contribute relevant data and information in order to address the climate crisis that Alaska Native peoples are experiencing.

Continued work and engagement are required to further develop responsive CBM programs in the Arctic. CBM programs are critical to support Alaska Native peoples in building a sustainable future that preserves culture and community. Below are some of the good practices and needs that were identified during the workshop and dialog.

In terms of good practice, CBM programs should:

- Be collaborative, co-producing knowledge and projects.
- Gather information that is relevant to communities and adaptation needs.
- Empower Indigenous peoples to address local decision-making needs.
- Utilize Indigenous and Local Knowledge (ILK) to fill information gaps, including documenting baseline environmental conditions.
- Avoid duplication by building on what is already in place.
- Build bridges between two worlds, Native and Science.
- Have data sharing agreements in place, which are co-created by all parties involved and clear to all participants.
- Share data with participating communities in locally accepted forms of communication for example in plain language reports, stories and newsletters.
- Contribute to communities through training, employment, and honoraria and by providing information needed to inform decision making needs.
- Be inclusive, including youth, Elders, and women.

In terms of needs, CBM programs need to:

- Shorten the distance from data collection to action by putting relevant information in the hands of those doing the adapting. Science is sometimes too slow to address the rapid changes people are experiencing.
- Collect data that is used to inform the management of wildlife, fish and the environment. Regulations are not keeping up with the fast changes people are experiencing, which can cause hardship for those living off the land.
- Enhance cooperation for sharing data.
- Understand that limited internet connectivity makes communication and real time data sharing difficult; find creative ways to effectively communicate.
- Engage communities in a greater role to identify monitoring needs with attention to changes that are occurring across many communities.
- Support networks of Native communities so that they may identify shared priorities and identify how science can best contribute.
- Work to change the system: Alaska Natives are forced to work within a system that doesn't reflect their way of thinking.
- Build trust and relationships.
- Support education, for scientists to understand Native ways, and for Native youth and others to get involved in science.

- Build effective networks so communities know what others are interested in and can share lessons learned about adaptation.
- Develop programs that monitor the impacts of industrial development.
- Work towards changing funding streams so that they support community priorities. Increase sustained funding opportunities for environmental monitoring. Educate funders about funding needs to properly document ILK. Support sustained priorities so they don't change with the 'political wind.'

The report for the workshop is available at:
https://intaros.nersc.no/sites/intaros.nersc.no/files/Intaros%20report%20final-WP4_Fairbanks.pdf

2.2.1.2 Canada

A workshop was held in Quebec at the Quebec Convention Centre on December 11-12 2017 concurrently with the Arctic Change 2017 Conference (proceedings in Johnson et al. 2018). This workshop offered an opportunity for practitioners of CBM programs from northern Canada to come together to exchange experiences and perspectives. Representatives of ten CBM programs attended; additional participants included representatives of co-management boards, northern research institutions, Inuit organizations, philanthropic organizations, and programs focused on developing or adapting tools for data management and sharing.

The objective of the workshop was to facilitate exchange of ideas and information among CBM practitioners from Canada about what is working well, what is not working or could be improved. Additionally, it should be discussed how more connections can be made between programs, data and information platforms to help build the field, raise the profile of CBM programs, and increase the use of CBM data and information within the Arctic observing community.

The workshop concluded that the motivations for implementing CBM programs differ but often include: influencing decisions about industrial development and regulations in fishing and hunting; better understanding challenges and opportunities of climate change; better understanding social and human health conditions, as well as education and capacity building. Likewise, the motivation for individuals to be involved in CBM varies but often include addressing the practical needs of communities for instance by influencing decision making. Other motivations for individuals included better understanding the environment, and sharing knowledge and learning from each other. There were multiple attributes being monitored by the CBM programs in attendance, although there were still many information needs and gaps identified.

A variety of people and organizations are using CBM generated information including: individuals, hunter trapper organizations, NGOs, industry, and government organizations at all levels especially wildlife management agencies. Good practices are considered practices that have proven to work well for CBM programs. These included for example CBM practices that are supported by the community, provide capacity building opportunities, connects ILK and science, and document ILK. Trust among community members and scientists is also important.
Challenges that CBM program representatives have faced include: the ability to secure long term funding leading to gaps in data records over time. Other challenges include reconciling science and community priorities, linking quantitative with qualitative approaches, and meaningful dissemination of information. There were also challenges related to avoiding misconceptions of how the data can be used, timeliness of producing accessible data, community 'burnout', and difficulties of growing a program. Other challenges included technical support that isn't available, limitations in community infrastructure and connectivity, and difficulties in creating credible and relevant information to influence change. It was expressed that we need to evolve CBM and not do things the way they have always been done, but build from what we have learned.

CBM sustainability can be enhanced through partnerships, and working together. This could lead to shared data platforms and better coordinated efforts to reduce redundancy. CBM programs that are able to be relevant and address the needs of communities, scientists and decision makers are likely more sustainable.

It is important for CBM information to be included in decisions about industrial development. Decision makers often need to understand large scale processes, which would require CBM programs to somehow connect with other programs and CBM data to be interoperable. This is sometimes difficult since CBM programs and community priorities vary.

Methods of data collection must be culturally appropriate. Community consultation to create data sharing agreements ought to happen before a project is implemented. All parties ought to be clear on what happens after the data is collected. The community ought to have opportunity to verify the data, and decide what data can be publicly available.

CBM organizers need to take into account the connectivity and infrastructure of rural communities. Data and information needs to be returned to communities, not just in summary form, but also the raw data as there may be a need for these data to be used for something else in the future. The technical challenges to data sharing are not as great as the jurisdictional and political challenges to data sharing.

Successful CBM programs build on mutual respect and understanding, which comes from listening and educating oneself. Certain people are talented at building bridges between science and Arctic communities. CBM programs ought to hire and support these individuals. It is important to politically consider the implications of the CBM program on Indigenous rights.
It was recognized that working together will improve long term success of CBM. Benefits of a network could include many aspects. It could help 'outside' researchers understand where the gaps are in what is being monitored to avoid duplication of efforts and make sure we are asking the 'right' questions. A network could contribute to better employment, and training and capacity building opportunities (e.g. could support micro financing). It could facilitate exchange of information to learn from others' mistakes and successes, in addition to better understanding how other communities have successfully dealt with change. A partnership could have a greater impact to advocate for CBM to be valued in decision making and for changes to funding structures.

A CBM network would need to be flexible, as communities are diverse. It is important to provide benefits to network participants, and recognize that participation may vary over time.

CBM programmes ought to:
- Connect with decision making needs
- Build community capacity e.g. training, employment, provide opportunity to learn from each other
- Be supported by the community
- Build trust among community members and researchers
- Utilize culturally appropriate data collection methods
- Have data sharing agreements developed and understood by all partners
- Consider connectivity issues and utilize creative ways of communicating effectively
- Return data to communities, including the raw data not just summaries
- Support individuals that can build bridges between communities and scientists
- Consider the political implications of the CBM program

CBM programmes are challenged by:

- Difficulty in securing long-term funding
- Reconciling science and community priorities
- Meaningfully disseminating information due in part to limited connectivity in many rural communities
- Avoiding misconceptions in how CBM collected data can be used
- Providing timely data
- Potential community 'burnout'
- Access to technical support
- Creating credible and relevant information to influence change, especially with industrial development
- Difficulties with data interoperability, since CBM is as diverse as the communities themselves.

The report from the workshop is available at
https://intaros.nersc.no/sites/intaros.nersc.no/files/Quebec_CBM_Report_Final%20%281%29_0.pdf

2.2.1.3 Arctic Russia

INTAROS has been implementing a community-based monitoring (CBM) capacity development process among selected indigenous peoples' communities in Arctic Russia since September 2017, Enghoff et al. 2019. The areas and sites involved include communities in Zhigansk and Olenek districts in Sakha Republic, Eastern Siberia, and Komi-Izhma communities in Komi Republic. The CBM activities are primarily being implemented in the various communities of Zhigansk and Olenek districts in Sakha Republic, which is home to the Evenk indigenous communities.

The indigenous communities involved are mainly fishermen, hunters and reindeer herders who are heavily dependent on the living natural resources in remote areas of the Arctic. All areas have indigenous communities making important local use of living resources but who are, at the same time, facing serious challenges in relation to accessing these resources due to changes in resource availability and threats, including pollution and resource depletion caused by various forms of mining and the oil and gas industry, as well as companies utilising and increasingly monopolising the fish resources. The areas are classified as traditional areas of occupational use. This is a legal status that gives indigenous communities in Russia a degree of protection but, in practise, it has proved difficult to enforce this status in relation to protecting the rights of indigenous communities.

The organisations involved in the CBM process are first and foremost the Centre for Support to Indigenous People of the North (CSIPN), the Republic Indigenous Peoples' Organisation of Sakha Republic and NORDECO (Nordic Foundation for Development and Ecology) from Denmark.

The CBM process has involved a wide range of workshops and meetings in the communities of the targeted districts. A total of 20 workshops and meetings have been conducted in the three districts, with an average of some 10-15 people involved in each one. The workshops and meetings have focused on introducing CBM and on building capacity to undertake CBM in the communities. Subsequent workshops have focused on how concrete CBM activities are being implemented in the respective communities. Different communities have been involved in the INTAROS CBM process for different lengths of time, with some starting in 2017, others in 2018 and a few in 2019. The status as of May 2019 is that eight different CBM groups are actively undertaking CBM within the targeted areas.

Key participants in workshops and meetings have included local fishermen, hunters and herders, local indigenous peoples' representatives, various members of local authorities, and school students and teachers.

Sakha Republic, Zhigansk and Kystatyam. Workshops were held in September 2017 and September 2018 in Zhigansk and Kystatyam in Zhigansk District, Sakha Republic. Here, involvement in CBM activities includes fishermen and hunters from Zhigansk; fishermen, hunters and herders in Kystatyam; and school students and teachers from Zhigansk School. In summary, the natural resources and the main issues discussed were:

- Fishing grounds and fisheries are being taken over by outside companies. A major change in the law has allowed for hunting and fishing rights to be bought, controlled and monopolised by outside companies through a system of auctions. In Zhigansk District, when locals attempt to fish, they are now frequently told to leave the area. Although indigenous demonstrations and boycott threats were organised in the Republic, this only helped bring about changes to the hunting laws. Fishing laws remained untouched, and these are of far more significance to the people. Fishing area auctions are still occurring and companies still control the majority of fisheries. Only subsistence fishing is allowed, and local people may only legally sell fish if it is through the companies, on their terms. The changes that are occurring with regard to the fishing areas and fishery resources are of crucial importance locally.
- Certain species of fish (first of all, Arctic cisco *(Coregonus autumnalis)* and Siberian cisco *(Coregonus sardinella*) are especially vital for the people, who have seen major changes in access to these fish. There is a decline in availability.
- Lake fishing involving Peled *(Coregonus peled)* and Siberian whitefish *(Coregonus lavaretus pidschian)* is a crucial resource. Lake fishing is experiencing major changes, and these are affecting people's livelihood opportunities.
- The domestic reindeer industry is considered to be in crisis. There has been a decline from 20,000 to only 3,000 in the area. There is reportedly plenty of pastureland, so this is not the problem. The issue revolves around the methods and measures for organising and supporting reindeer husbandry, which are not currently conducive to the industry. The availability of suitable food, the right reindeer lichen, is also a topic that requires better understanding, however.
- Wild reindeer are an important resource in the area, especially for local hunting. The populations of wild reindeer have been in decline, so knowledge of their numbers and movements would be invaluable.
- Moose is another important natural resource. The population has been steadily decreasing, with hunting rules - such as the need not to shoot females - widely disregarded.
- Sable (*Martes zibellina*) is traditionally an important animal, locally hunted for the fur trade. The income from hunting sable has reduced significantly, and practices are no longer environmentally or economically sustainable.
- Wolf populations are increasing in numbers; this is considered worrying by the community members as wolves are an increasing threat to domestic reindeer and to people.
- Brown bear populations are also a growing threat to the local people due to increasing numbers of attacks and encounters close to villages. It is difficult for locals to control the numbers of brown bear due to a lack of licenses for bear hunting. People are increasingly afraid to go into the forest.

Key resources that the CBM groups in Zhigansk and Kystatyam are monitoring include:

- Availability of fishing areas and rules regarding fishing as well as fish prices
- Arctic cisco (*Coregonus autumnalis*) in the Lena River in summer and autumn (catch, size and time of occurrence)
- Water quality in Lena River
- Siberian cisco (*Coregonus sardinella*) in the Lena River during winter time (catch, size and time of occurrence)
- Lake fish (Peled - *Coregonus peled*, Siberian whitefish - *Coregonus lavaretus pidschian*)
- Reindeer husbandry (methods of reindeer husbandry support)

- Wild reindeer (population dynamics)
- Moose (distribution, population dynamics)
- Brown bear (population dynamics)
- Wolf (distribution, population dynamics)
- Sable (population dynamics)

Sakha Republic, Olenek, Kharyalakh and Zhilinda. Workshops were held in September 2018 and April 2019 in Olenek, Kharyalakh and Zhilinda. Here, involvement in CBM activities includes hunters and fishermen from Olenek; hunters, fishermen and herders from Kharyalakh; and hunters, fishermen and herders from Zhilinda; as well as school students and teachers from Olenek School. In summary, the natural resources and the main issues discussed were:

- Wild reindeer. The hunting of wild reindeer is the most important resource for the local communities of the area. The occurrence of wild reindeer is dynamic and changing. Hunting restrictions are not aligned with the actual numbers of wild reindeer. The local communities consider that the hunting quotas and licenses have been unreasonably reduced by the authorities. Overall, the population of wild reindeer has increased but major changes in abundance are occurring from year to year. Wolf predation on the wild reindeer population is significant. Major worries are that hunting of wild reindeer will be negatively affected by future developments, including industrial. A better understanding of wild reindeer migration routes is needed.
- Domestic reindeer. Olenek District used to have a large domestic reindeer production but this has decreased sharply in recent decades. Domestic reindeer production is facing many problems. One key issue is the very substantial wolf predation on the domestic herds, resulting in losses of up to 20-25% of the animals per year. Pasture quality is also an issue in reindeer herding.
- Wolf. There has been a sharp increase in the number of wolves. This is a major problem, especially for domestic but also for wild reindeer. The reason for this increase is considered to be a lack of effective wolf control measures.
- Industrial mining development. There were major concerns raised in all the villages with regard to the various ongoing and planned industrial developments in the area. The concerns relate to water pollution, air pollution (radioactive from rare earth metal mining) and to the blocking of reindeer migration routes and overutilization of living resources in and adjacent to the industrial sites.
- Water quality of the river. Drinking water quality is a major concern for people. The quality of fishing water is also important. There are fears that water quality is deteriorating.
- Sable. Sable are important for the fur trade although prices have reduced significantly. The population is considered to be stable.
- Brown bear. Numbers are increasing and people are increasingly afraid of encountering bears.
- Fish population, including Tugun, or Tugunok *(Coregonus tugun)*, a small fish very important for the livelihood of the Olenek people, and Arctic grayling *(Thymallus arcticus)* are understood to be declining in the area. Fishing license policy does not currently support local people.
- Berries. Berries are very important for people and there is a need to ensure continued supply.

Key resources that the CBM groups in Olenek, in Kharyalakh and in Zhilinda are monitoring include:

- Wild reindeer
- Berries
- Brown bear
- Wolf
- Tugun, Tugunok *(Coregonus tugun)*
- Arctic grayling *(Thymallus arcticus)*
- Water quality

- Polar fox
- Sable
- Lenok (a fish) – *(Brachymystax lenok)*
- Pike
- Domestic reindeer and pasture quality

The general status of the CBM process is that local communities and local indigenous peoples' representatives are interested in and supportive of the CBM activities. CBM activities are well underway in a number of areas of Sakha Republic. The use of CBM is generally understood and seen as a relevant activity that will provide the local communities with an improved way of developing and presenting local knowledge on resources and resource use. Local authorities are supportive of the activities. The Republic Indigenous Peoples' (IP) organisation is taking a leading role in activities and ensuring linkages to the communities. Input from the CBM groups (information, analysis and recommendations) has been used by the Republic IP organisation to seek influence over the management of a number of subject areas related to resource management at both Republic and District level. Organising and communicating information is being undertaken using short and relevant forms, which are filled out by the CBM groups and which include resource information, analysis of information and suggested actions. A summary of the impacts of CBM activities so far includes:

- Project participation is linking well with the process of seeking to put the territories of traditional land use into practise rather than being merely a classification on paper, as they are now. The work with the CBM groups is helping the IPs to become more the *subjects* of the development of the traditional land rather than just the *objects* of its development. This contributes to more active local people. It also contributes to monitoring the various industrial developments (mining) that are being undertaken and planned on traditional territories. The CBM work is thus a tool that contributes to a dialogue between the extractive industries and the owners/users of the traditional lands.
- An *obshina* (community) in Zhigansk has obtained the rights to a traditional fishing ground partly because of its active participation in the CBM group project. This work empowered the obshina and gave extra clout to their process of obtaining the rights.
- Information on fishing and the challenging of fishing net sizes from the CBM groups, where the CBM groups have established that two most important fish – Siberian cisco and Arctic cisco – species are swimming deeper due to warmer waters and are therefore difficult to catch with the permitted net types. This action has been used by the IP organisation at several meetings with the Republic's authorities, who then refer the matter up to the Federal authorities.
- Information on brown bear problems has been promoted at several meetings with the Republic's authorities in order to seek better solutions by which local people can protect themselves from bear attacks.
- The information on wild reindeer hunting shows that this is very important and that local people are worried about its future due to industrial development (mines). The IP association has taken this to the mining company and agreed a monitoring programme for wild reindeer with them. Information on wild reindeer populations and their strong fluctuations, as well as the mismatch with set hunting quotas, is also being used to influence the authorities' decisions on management of reindeer hunting.
- Monitoring has raised problems of water pollution around the Alrosa diamond mining sites. The IP organisation has taken the problem of water quality monitoring to the District- and Republic-level authorities.
- Establishment of the CBM groups has generally resulted in much more important information reaching the IP association from the communities and this is proving useful in dialogues with the authorities.
- The IP organisation in Zhigansk District has become more active due to the introduction of the CBM activities. - -

2.3 Information collected by other EU projects and organisations

A number of Eu funded FP7 and Horizon 2020 projects as well as other organisations has performed user surveys. A short summary of their findings will be given in the following sections.

2.3.1 SIDARUS

SIDARUS was a three-year EU FP7 project running in 2011 - 2013, The overall objective of SIDARUS was to develop and implement a set of sea ice downstream services for polar users and stakeholders in the area of climate research, marine safety and environmental monitoring. SIDARUS will extend the present GMES/Copernicus services with new satellite-derived sea ice products, ice forecasting from regional models and validation of sea ice products using in situ data.

SIDARUS focused on three different user segments, Marine safety, Marine and costal environment and Climate and seasonal forecasting. Each of the user segments has unique requirements for parameters to be observed, accuracy of data, re-visit time etc. based on the products or services to be delivered. It was therefore important for SIDARUS to assess the requirements of their focus user communities; this was don via questionnaire survey focusing on sea ice and weather products. The last parts was developed in close cooperation with WMO's Executive Council Panel of Experts on Polar Observations. In total 24 potential users were invited to the survey of which 18 accepted the invitation and replied to the questionnaire.

The main findings of the SIDARUS user survey was:

- Among the most important parameters are ice concentration, edge, type, drift, deformation and ice thickness. For near real time operators, a demand of high spatial resolution is requested. The need for sea ice forecasts is especially highlighted by the Marine Safety segment where 2-3 days of forecast are most useful. Ice berg is only requested by this segment and occurrence, size and drift are all valuable information.
- Snow cover and water on ice are more important for the Marine and costal environment and climate and seasonal forecasting segments.
- The most important weather and oceanographic parameter for the Maritime Safety segment seems to be wind and ocean current. The other segments have a more general need for weather and ocean parameters.
- The preferable delivery mechanism for all users is web download but for operational units there is also a demand for other delivery methods such as data delivered directly in Electronic Navigation systems, e-mail, AIS and Navtex.
- Discoveries made in SIDARUS survey is consistent with results from previous studies and shows that there is still an unmet need for sea ice data.

Some of the main points given by the responses from the questionnaire are summarized in Appendix 3 (SIDARUS, 2011).

2.3.2 ACCESS

ACCESS (2011-2015) was a European Project supported within the Ocean of Tomorrow call of the European Commission Seventh Framework Programme. Its main objective was to assess climatic change impacts on marine transportation (including tourism), fisheries, marine mammals and the extraction of oil and gas in the Arctic Ocean. ACCESS also focused on Arctic governance and strategic policy options.

The ACCESS consortium performed in 2011 a survey on user requirements for ice and met-ocean information by sending a questionnaire to a variety of user categories. They received in total 21 replies representing the different user sectors as shown in Fig. 2.1.

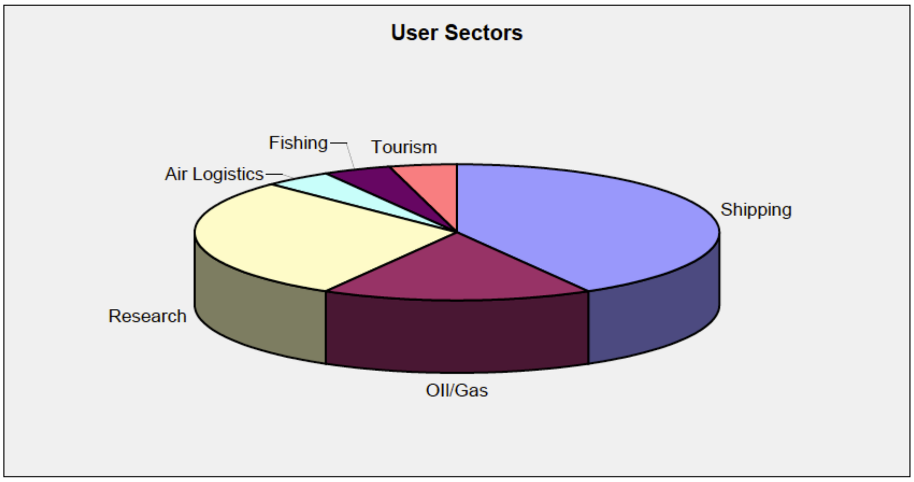

Figure 2.1 User sectors responding to ACCESS survey

ACCESS concluded from their survey (ACCESS, 2012):
The overall conclusion that can be reached from the results of the questionnaire are that the users of sea ice charts require as much information on different parameters as possible with the best detail available, and this made available to them as often as possible. Most of the need is for tactical information, with only some requiring operational and strategic forecasting for their activities.

Although there was a good ratio between shipping, oil/gas, and research among the organisations that responded to the questionnaire, there was a strong bias towards Norwegian respondents that affected the questions asked about interest in geographical areas towards local sea regions. This should be addressed further in the follow-up questionnaire when the users are presented with predictions of climate change and asked how their information needs would change.

There is a strong demand for all the different parameters of sea ice information. Some of these, particularly sea ice thickness, require more work to be done by the scientific community before that information can be made available in a reliable way to the operational organisations producing sea ice maps. New ways of presenting information on some sea ice parameters, that go beyond the standard WMO and Ice Services symbology's, will have to be developed.

The requirement for as much detail in the mapping as possible, with frequent updates, suggests that:
- more work be done on the assimilation of high-resolution data products derived from satellite sensors such as SAR and optical into forecast models, and
- that outputs of these models are made available more frequently, or in a way that users can plot ice information based on a combination of assimilated data and model forecast for a particular time that they require.

Under half of the responding organisations required strategic forecasts. This is partly because only some user sectors require planning of their investment that far ahead, and also due to some lack of awareness of how long-term changes to conditions may affect their operations.

Detailed information from the survey are reported in ACCESS, 2012 and the most relevant results are presented in Appendix 4.

2.3.3 EU-Polarnet

EU-PolarNet is a Coordination and Support Action to develop and deliver a strategic framework and mechanisms to prioritise science advise the European Commission on polar issues, optimise the use of polar infrastructure, and broker new partnerships that will lead to the co-design of polar research projects that deliver tangible benefits for society. By adopting a higher degree of coordination of polar research and operations than has existed previously the consortium engages in closer cooperation with all relevant actors on an international level. INTAROS is using the documents provided by EU-Polarnet in the assessment of existing observing systems. INTAROS is also collaborating in dissemination activities at Arctic conferences and stakeholder events.

Eu-Polarnet has a dedicated work package on Stakeholder interaction with the following objectives

- Initiate, conduct and sustain an on-going dialogue and cooperation with all relevant stakeholders for the Polar Regions.
- Support meaningful interactions between scientists and stakeholders to shape the future polar research agenda, exchange key information and priorities, and foster joint involvement in the research process.
- Develop innovative approaches to bridge disciplinary and cultural gaps to integrate multiple types and sources of knowledge, visions, needs and preferences.
- Establish trans-disciplinary collaboration on polar research by bringing together natural scientists, social scientists and stakeholders.
- Embed the concept of social and economic relevance within the research programme.
- Provide evidence to demonstrate the use of data and research results by end users.
- Develop a suite of innovative combination of stakeholder engagement and analysis techniques to guarantee efficient interaction.
- Equip EU-PolarNet participants with “tools” and resources to development engagement plans.
- Provide flexibility of approach to cope with the evolving project needs.

Altogether EU-PolarNet conducted in 2015-2018 twelve stakeholder events and two online surveys. Every event focused on one varying theme related to a topical Polar issue and included presentations and/or panel discussions involving different stakeholders (e.g. Industry, policy makers, and Arctic Indigenous Peoples) and researchers. The outcomes of the stakeholder events were used to identify the societal needs and challenges for the development of the Integrated Polar Research Programme and for learning and sharing information on best practices in stakeholder engagement and finally for giving recommendations on successful stakeholder engagement. The result has been summarized in two documents:

- Deliverable D4.14: Completed stakeholder consultations, report on the needs, gaps and opportunities produced,
- D4.15: White paper on status of stakeholder engagement in polar research.

The first is a report on a number of stakeholder events from 2015-2018 and results from a stakeholder questionnaire, while the second provides useful guidelines on how to work with stakeholders

The focus for EU-Polarnet was to map stakeholder requirements to and interaction with Arctic science and research priorities, so their result, although very interesting in the right context, is not so relevant for this INTAROS survey focussing on requirements to products and services to users primarily the private industry.

More info at https://www.eu-polarnet.eu/project-themes/interaction-with-stakeholders/

2.3.4 SALIENSEAS

SALIENSEAS project is part of the ERA-NET program initiated by JPI Climate and is funded by NOW, IFD, RCN and FORMAS, with co-funding of the European. SALIENSEAS brings together a team of social and natural scientists, met-ocean service personnel, and end-users in an iterative research and co-production process. Stakeholders and end-users are directly involved in the project, both as advisors in the project management and as respondents and participants in end-user workshops. Objectives of the project are:

- Understand the mobility patterns, constraints, challenges, decision-making contexts and information needs of end-users in different European Arctic marine sectors;
- Develop and apply participatory tools for co-producing salient weather and sea ice services with Arctic marine end-users;
- Co-develop user-relevant and sector-specific weather and sea ice services and dissemination systems dedicated to Arctic marine end-users tailored to key social, environmental and economic needs.

SALIENSEAS has organised two user consultation events:

Stakeholder workshop

January 2018 a workshop was organised for the SALIENSEA Stakeholder Advisory Group to discuss important information needs pertinent to planning and operations in their sectors. Relevant in these discussions were planning routines, uncertainties that may arise due to weather and ocean conditions and services needed when considering alternate courses of action, Lamers et al, 2018.

The workshop participants noted that they themselves, and the stakeholders they represent, looked at and compared notifications from multiple sources. This may indicate that they, in order to assess how reliable and accurate various information products are, engage in a verification process before they translate any information into various decisions and actions. This verification is especially pertinent during a 24-hour timeframe ahead of voyages. Generally, the stakeholder representatives emphasized the importance of improving monitoring and short-term forecast products across the different areas that were discussed.

Notable observations made during the initial reflections:

- Wind along the ice edge, katabatic wind, and storm events are relevant to many stakeholders.
- Polar Low events are also of interest, although the degree to which forecast lows impact operations depends on the type of activity planned.
- Experienced navigators prefer annotated satellite images to coloured ice charts.
- The coloured ice charts are valuable for the egg codes they contain, as these communicate information regarding the inhomogeneity of the sea ice, and are obligatory products to meet the requirements of the Polar Code.
- Many users are unaware of the suite of met-ocean services offered; a centralized depository for information, or comprehensive guide would be very helpful.
- Navigators on large-scale operations subscribe to a vast array of services and receive large amounts of information, much of which could be better automated to aid in planning.
- Increasingly, there is a need for a dedicated ice advisor whose role is to distil and interpret information into operational planning.

User survey

January – May 2019 the project performed an online mapping survey targeted to map which Weather, Water, Ice and Climate (WWCI) parameters is needed about the situated context of maritime activities around Greenland and Svalbard, Jeuring and Knol-Kaufmann, 2019

Most of the respondents currently have professional occupations on vessels that sail in Arctic waters. A small number has a job on shore, assisting vessels or working on planning and logistics. The majority represents the cruise tourism sector, while fisheries, cargo/supply, passenger transport and maritime research are represented too. Key findings include:

Voyage planning

- Voyage planning is interpreted as a multidimensional practice, of which the significance and content changes across temporal levels and differs between maritime sectors;
- Uncertainty about and adaptation to WWIC conditions are strongly embedded in any type of maritime activity, and the liberty to stray from specific parts of voyage plans is necessary in order to successfully carry out an overall voyage or operation.

Tasks and activities sensitive to adverse WWIC conditions

- WWIC conditions have a nuanced, yet significant, impact on different maritime activities, at different locations;
- Tasks and activities which are particularly sensitive to adverse WWIC conditions are port calls, the navigation of certain (often narrow) areas, and cruise tourism activities such as landings and excursions;
- Activities appeared to be most sensitive to sea ice related factors. Almost 90 percent of drawn activities were stated to be very or extremely sensitive to adverse impacts of variability in sea ice concentration. Other important factors that stood out were wind (both speed and direction), followed by horizontal visibility and wave conditions;
- The impact of adverse WWIC conditions varies, from increased uncertainty in route planning and choice of equipment, to difficulties to execute planned activities, decreased passenger comfort, or the need to build in spatial or temporal flexibility in voyage planning and execution.

Information (in)accuracy and (in)sufficiency

- While respondents have indicated that there are many instances where they do not have enough information (information insufficiency), they seem generally satisfied with the accuracy of the WWIC information that is available;
- Respondents often experience information insufficiency regarding sea ice and wind (sea ice concentration, sea ice thickness, sea ice extent, wind speed and wind direction). Importantly, planning and operations are considered most sensitive to the variability of these same conditions;
- WWIC information services are experienced to have a limited and unequally distributed geographical coverage. Whereas some areas are well covered, like South Greenland, or Isfjorden and the area around Longyearbyen in Svalbard, the available information for geographical regions outside these “centre’s” is experienced as insufficient to a greater _degree;
- Limited download capacity constrains access to information sources is an important challenge for maritime activities in the high north;
- Sharing of experiences with (in)accurate WWIC information with NMHSs occurs on a limited basis.

Discussion and recommendations

There is a strong need to further uncover how the multidimensionality of voyage planning is put in practice, especially because voyage planning is increasingly embedded in regulations, such as SOLAS and the Polar Code.

Access to sufficient and accurate information about sea ice and wind conditions is most vital to many operators in the Arctic, and should be the focus of the further development of Arctic forecasting.

Additional suggestions for improvement of services pertain to local wind and wave information (both direction and height). Importantly, there appears to be a desire for products that can convey *dynamics* of WWIC conditions, for example through interfaces depicting sea-ice drift. Aligning with findings elsewhere (see also Dawson et al., 2017), there is a need to increase the frequency of sea-ice charts and to bridge the gap toward communicating real-time sea ice information as much as possible.

There is a need to deal with existing technological limitations and find solutions at the local level that can provide some legroom for at least some maritime stakeholders. For example, testing out new interfaces or products (low-bandwidth WWIC information distributed via email) before rolling it out to larger groups of users. Other options include investing in WWIC services for local communities along the Greenland coast; making available paid services to vulnerable stakeholders with limited funds (e.g., small scale fisheries); or target development of high-resolution products at especially challenging areas for navigation (e.g., Prince Christian Sound, ports or cruise landing sites).

Despite a number of methodological limitations, online participatory mapping provides concrete entrances for in-depth interactions between providers and users of WWIC information, especially when integrated in a stepwise data collection and subsequent co-production practices. Overall, this report calls for continuous efforts to obtain insights in needs for WWIC information services of maritime stakeholders by considering the spatially and temporally salient practices of planning and executing maritime Arctic activities on a detailed level as possible.

2.3.5 International Ice Charting Working Group

The international Ice Charting Working Group (IICWG) decided in 2018 to conduct a survey among mariners operating Polar Waters for better qualitative and quantitative understanding of requirements, needs, gaps, trends, limitations of current/future products and services. The survey was conducted during the spring 2019 and reported to the IICWG Annual Meeting in Copenhagen September 2019. Detailed results are given in Appendix 5.

The ICCWG Task Team responsible for the survey identified a number of key messages to the ice services from the Mariner Survey:

- Know your user base
- Interact with your user base
- Ice services to the marine community must be characterized by being relevant, accurate, reliable, actual and accessible. This is more important than ever.
- The mariner requirements trend goes towards better resolution and frequent updates and ability to see hazardous ice (scale: 100-200m or less, sub-daily updates for certain regions)
- Satellite data must have necessary resolution for ice charting. Kilometre scale resolution should be avoided for ice analysis to navigational applications.
- Tailored ice information for certain dynamic or critical locations is important.
- Ice information as a risk product is important
- Local/regional high-resolution forecast products for next 24-48 hours are essential for safe/efficient navigation in/near ice.
- Improved access to scalable ice information including ingestion to onboard systems, keep graphical formats for other displays.
- Extended access to automated / annotated satellite quick looks for particular/critical areas. The need for mariner training on image analysis is not surveyed.

Specific comments from mariners:

- Digitize (ice information), increase asap update speed - to possible live streaming of sat info for advanced ice navigators!
- Access to real time websites from a ship sailing on Polar Waters is very important to obtain the latest ice images/charts & local government info on location of nearest icebreaker(s). As Master or Ice Navigator, you always want more information on your current situation to make the best (safest) decisions for your vessel. Also, it is quite useful to keep the ice charts/info flowing to the ship if she is making repeat voyages during the summer months to the same area, again- this is to maintain situational awareness so there are no surprises!
- Products available in ECDIS format are essential.
- Prefer SIGRID-3 charts with iceberg data, pressure and drift data to cover the Arctic region including Beaufort Sea, Northern Sea Route shipping corridors. I am currently using SIGRID-3 charts for East & West Arctic which is very useful indeed.
- There are challenges converting between Mercator and polar stereographic formats. Utilizing a non-standard navigation suite to upload ice imagery (SAR); no means to integrate with ECDIS.

Other Information

There were a few suggestions for other types of ice information:

- Webcam at critical positions
- More ice information in areas with high current, where ice is drifting a longer distance in a short time.

But one respondent has a different idea:

- As an official, I would not give too much information to merchant vessels trading in the Baltic Sea. This is because of the large number of vessels. The system is built to serve all vessels with limited Icebreaker capacity. Routes through the ice-covered areas are given by the authorities and if the vessels start to navigate elsewhere, the traffic flow will slow down $due to lack of assistance capacity. In other Arctic areas, the situation is different and all possible info is good to give.

Communication

- “The current problem for clients operating in many jurisdictions is the lack of connectivity in order to receive the much-needed ice information. Recommend more focus on delivery of products to these areas, such as the Canadian Arctic (e.g. above latitude 68°N)”
- “Radio facsimile updated twice daily at set times is simple but effective. It automatically catches updated charts, does not need an internet connection, nor requires a person to go away from his work to access (especially important when the ship is in vicinity, or in ice covered, waters. … an afternoon and evening fax time for the auto timer on board is simple and efficient. Next would be … access (to) your national website (but) could not from ship. The third way is for our charter ice info service (to include it in the) late afternoon daily round-up of ice and weather info. We access up to date Canadian ice charts by checking on line if we have reception and we suspect a new chart is due. - if we can spare the time to look.”
- Vessel operates at high-latitude well outside of cell range. Almost all ice information is received over internet sites & ftp from NIC. Internet connectivity (primary means of obtaining ice imagery) is lost at 74°N. Secondary communications is through Iridium, but has delays and sporadic reception. Images contracted (from private supplier) are 12-24+ hours in latency. Useful for strategic/long-term planning (e.g. let's go 50 NM in this general direction), but not useful for tactical, real-time transits (e.g. there is an open lead 2 NM to the east)
- High-latitude connectivity is degraded. Need better satellite coverage/bandwidth

2.3.6 Copernicus

The Copernicus Services and Space Component deliver a wide range of data and products with relevance for the Arctic region. Furthermore, important in situ data collection, rescue, and quality assurance activities are carried out as an inherent part of Copernicus production workflows. Thus, Copernicus is contributing significantly to the Integrated Observing System operating in the Arctic.

Access to data from sources other than satellites is indispensable for the generation and quality of Copernicus products, and for the Space Component to play its full role. Furthermore, as Copernicus is an operational programme, such data need to meet stringent requirements regarding availability and quality. The Copernicus In Situ Coordination activity led by the European Environment Agency (EEA) has launched a study with the purpose of clarifying to which extent the necessary in situ data from the Arctic region are available to the Copernicus programme in order to:

- Maximize the exploration of present and future Copernicus Sentinels
- Produce and validate products from the Copernicus Services – in particular CMEMS, C3S, and CAMS

The objective of the project was to provide an analysis of:

- Requirements for meteorological, ocean incl. sea ice and cryosphere in situ data in the Arctic region by Copernicus Services and Space Component;
- Existence and availability of the requested data incl. identification of condition for accessing restricted data (payment, use restrictions etc.);
- Identified gaps.

The project was implemented during the first half of 2019 resulting in a comprehensive report which subsequently have been reviewed by the relevant Copernicus Services, EUMETSAT and ESA.

Main Results

The Copernicus Services and Space Component requirements for in situ data in the Arctic Region has been collected and analysed. The analysis shows that it is mandatory for Copernicus to have timely access to a broad suite of in situ observation in sufficient quality and resolution in time and space. The Copernicus community has clearly articulated which variables are essential for their production line as well as their requirement for timely delivery and quality, while the resolution in time and space still is open for further clarification. The latter issue is being addressed in the Copernicus In Situ Coordination Information System (CIS^2) under establishment within the Copernicus In Situ Component led by the EEA.

The project group has collected a comprehensive, although not complete, overview of existing in situ data from the Arctic, i.e.:

- Data already used by the Copernicus Services and Space component;
- Data freely available at various national and international data repositories but still not used in the Copernicus production line;
- Data with restricted availability due to institutional and/or national data policies;
- Data collected in research projects without a data management structure enabling a free data exchange.

The gap analysis has identified two groups of data gaps: Observations needed but do not exist. This kind of gap can be roughly identified by comparing the requirements and spatiotemporal distribution of the observations, and observations that exist but are not being used because:

1. Data are not freely available due to e.g. data policy, lack of institutional data management structure, delayed release from research projects, need for revenue generation, technological confidentiality and even political issues.
2. They do not fit Copernicus purposes due to
   a. Untimely availability - most of the applications have strong time constrains, e.g. near real time forecast and validation need observations in near real time; interim reanalysis needs observations in interim scale, i.e., 1-12 months before production time;
   b. lack of sufficient metadata;
   c. Inadequate quality - observations for Copernicus must fulfil certain quality standards.

In addition to the data gaps, two important challenges have been identified:

- Technology gaps. The harsh and remote environment puts special demands on the instrumentation for in situ observations as well as data communication in near real-time, and the existing technology and infrastructure is extremely costly. The gap in technology has up to now put limitations on the monitoring of the Arctic, so there is a need to find innovative cost-effective technological solution for Arctic observations securing continuous NRT data flow from this harsh environment also during wintertime;
- Sustainability gaps. Sustainability of observation is highlighted as very important to maintain areal coverage and long timeseries. The sustainability problem has recently been investigated and documented by the Copernicus In Situ Coordination Component (Buch et al, 2019) showing severe sustainability problems for European in situ observations in general - particularly for atmospheric composition and ocean observations. The present analysis shows that the sustainability issue is more outspoken in the Arctic for all thematic domains, since many in situ observations rely on time limited research funds.

General conclusions

The analysis leads to the following general conclusions:

- Environmental in situ data from the Arctic are managed by national data centres, international data centres, funding agencies and individual research project, both in countries with Arctic coastline and countries with an Arctic interest;
- National observations programmes generally meet national priorities and lack international coordination;
- The purpose of using in situ observations in Copernicus ranges from calibrating and validating satellite sensors and algorithms, numerical models, to assimilation into operational and re-analysis model prognoses. In addition, for the climate service, consistent and long-term observations are needed to identify the trend and long-term variability of the climate;
- In situ observations are very sparse in the central Arctic;
- Due to lack of good communication facilities, many data are delivered in delayed mode thus being untimely for particularly NRT productions. Other data e.g. research data are made publicly available too late to be available even for interim re-analysis purposes i.e. there is a need for internationally agreed standards for timely delivery delayed mode data taking into account scientists right to publish;
- The Arctic environment put high demands on robust technology and there is outspoken demand for pursue innovative technology development;

- Several services express that the limited amount of data is a bigger problem than the quality of data, although poor data quality in itself is problematic;
- Insufficient data management structures at data producer level constitutes a big problem which negatively affects:
  - Formats of data and metadata;
  - Accessibility;
  - Timely delivery;
  - Quality documentation.
- Access to Russian data are extremely limited and calls for a dedicated action to free more critical observations in cooperation with Russian authorities;
- The given heterogeneity of the data sources implies that:
  - Automated data quality control is difficult and poor quality can consequently significantly impact verification results;
  - It is important that data are collected at sites which are representative of their wider area rather than their immediate surrounding.

Next steps

The analysis has underlined the need for initiating dedicated actions to improve the availability and accessibility of critical in situ data to meet Copernicus' needs. It is however important ensure proper coordination with other key European and international initiatives, e.g.:

- The Sustaining Arctic Observing Networks (SAON) is a joint initiative of the Arctic Council and the International Arctic Science Committee that aims to strengthen multinational engagement in pan-Arctic observing. SAON has recently approved a strategy and implementation plan covering the 2018-28 period;
- WMO, IOC and GEO all have a strong focus on the Arctic region due to the fact that climate changes are happening faster and is more pronounced in this region;
- EU has funded several H2020 projects with focus on the Arctic region. These projects have and are collecting a lot of valuable information towards design of a fit-for-purpose observation system e.g. user requirements for products and services, operation of some observation system although limited in time, etc. EU has established an Arctic Cluster for internal coordination between these projects. It would especially be important to establish links to the INTAROS project which has a major goal to establish a roadmap towards a sustained Integrated Arctic Observations System;
- Relevant national authorities since the implementation of a future sustained Integrated Arctic Observing System will rely heavily on national funding. In this respect it will also be important to investigate ways to involve indigenous people in the implementation.

As a practical way forward, Copernicus is considering the feasibility of the following short-term actions that need to be implemented in a coordinated and collaborative manner:

- Establish formal links to intergovernmental bodies such as SAON, WMO, IOC and GEO to secure that Copernicus' requirements for a sustained and integrated observing system are articulated and taken into account;
- Liaise with Horizon Europe to promote that
  - Arctic relevant observing technology and data communication development is included in future research calls – focus could be on multipurpose and autonomous observing platforms;
  - Research projects are requested to secure free exchange of data along the FAIR principle using existing European data management infrastructures.

- Continue to setup and leverage international cooperation arrangements between the EU and non-EU countries with an Arctic interest, e.g. Canada, South Korea, Japan, and the USA;
- Continue to define and document Copernicus specific requirements to an Arctic in situ observing system – attention should especially be on:
    - Resolution in space and time;
    - Data quality improvement;
    - Metadata improvements.
- Pursue innovative cost-effective technological solutions for Arctic observations securing continuous NRT data flow from this harsh environment also during wintertime;
- Initiate data rescue activities composed of but not limited to the following components:
    - Continuous support of projects like the C3S inventory effort, enhanced data collection, homogenization and mining;
    - Maintain and further develop centralised data portals for the individual thematic domains;
    - Start a task force focussing on unlocking existing data presently not available to Copernicus. The effort could include support to organisations without a proper data management structure, support to implementation of proper data quality control procedures;
    - Improve access to Russian data sources for all thematic themes in cooperation with relevant Russian authorities.

3. Transferring user requirements into design of an Arctic observations system

With a detailed overview of the user's requirements for products and services, it is possible for the service providers to plan how to address these requirements. A typical operational production line consists of the following elements:

- Observations – collecting information on the present state of environment. This element includes remote sensing and in situ data collection
- Forecasting – running numerical model simulations to predict developments in near future. Numerical models are also used to perform re-analysis to reproduce detailed information's and developments over past years to decades
- Product generation – based on the information produced via observations and model simulations information, products and services are generated in a format tailored to the individual user/user group

Based on the information collected by INTAROS and reported in the previous chapters of the present reports it is evident that users have high demands to the resolution in time and space for their requested products and services. Such resolution can only be delivered by satellite observations and model outputs. Additionally, due to the hostile environment in the Arctic, it is foreseen that monitoring of the Arctic region will rely heavily on satellite observations. Both satellite observations and numerical models require calibration and validation against in situ observations and especially for the ocean there is need to supplement satellite observations by more traditional in situ platforms such as ships, profiling floaters, gliders, moorings, AUV's etc. to monitor the interior of the Arctic Ocean. It is therefore mandatory for service providers to have timely access to a broad suite of in situ observations in sufficient quality and resolution in time and space.

INTAROS and the Copernicus has recently performed surveys on the requirements for and availability of in situ data for the Arctic region (INTAROS, 2018 a,b,c and Buch et al, 2019). Both surveys identified severe gap in the availability of in situ data from the Arctic and a detailed analysis of the gaps has identified two groups of data gaps:

- Observations needed but do not exist. This kind of gap can be roughly identified by comparing the requirements and spatiotemporal distribution of the observations.
- Observations exist but are not being used because:
    - Data are not freely available due to e.g. data policy, lack of institutional data management structure, delayed release from research projects, need for revenue generation, technological confidentiality and even political issues.
    - They are not fit for purpose because:
        - Untimely availability - most of the applications have strong time constrains, e.g. near real time forecast and validation need observations in near real time; interim reanalysis needs observations in interim scale, i.e., 1-12 months before production time;
        - lack of sufficient metadata;
        - Inadequate quality - observations for Copernicus must fulfil certain quality standards.

In addition to the data gaps, two important challenges have been identified:

- Technology gaps. The harsh and remote environment puts special demands on the instrumentation for in situ observations as well as data communication in near real-time, and the existing technology and infrastructure is extremely costly. The gap in technology has up to now put limitations on the monitoring of the Arctic, so there is a need to find innovative cost-effective technological solution for Arctic observations securing continuous NRT data flow from this harsh environment also during wintertime;

- Sustainability gaps. Sustainability of observation is highlighted as very important to maintain areal coverage and long-time series. The sustainability problem has recently been investigated and documented by the Copernicus In Situ Coordination Component (Buch et al, 2019) showing severe sustainability problems for European in situ observations in general - particularly for atmospheric composition and ocean observations. The present analysis shows that the sustainability issue is more outspoken in the Arctic for all thematic domains, since many in situ observations rely on time limited research funds.

It is therefore extremely important to establish a set of internationally agreed requirements for in situ observations including which parameters are important to observe and in which resolution and time and space, quality demands and timeliness for delivery.

When this known the process of designing a fit-for-purpose observations system can start which automatically also will address the issue on which technology to use -and develop if needed. Data communication represents a special challenge in the Arctic and will require special attention.

The process of establishing requirements for in situ observations has been initiated by World Meteorological Organisation (WMO) for meteorological variables and the Global Ocean Observing System (GOOS) for ocean variables. The Copernicus In Situ Coordination has recently initiated a database on requirements for in situ parameters for meteorology, ocean, atmospheric composition, and climate, an example of the content is shown in table 3.2.

This process is however in its initial phase so there is demand for an international dialog to a setup and agree on requirements to observation of Arctic Essential Variables taking into account what is feasible logistically and economically.

The importance and complexity of defining realistic requirements can be illustrated in the following example:

Arctic Ocean has been selected as a test basin. The Arctic Ocean has an area of 14.056.000 km^2

Both T/S and Oxygen profiles are according to the GOOS definitions required to have a horizontal resolution of 100 km as threshold value which mean that the Arctic Ocean shall have 1400 observation points. If requirements for horizontal resolution were 300 km (the resolution the ARGO programme aims to maintain) the number of observation point in the Arctic Ocean would be 155.

The threshold value for time resolution is 7 days for T/S profiles and 90 days for oxygen, the breakthrough values are 1 day and 30 days respectively.

The required observations per year together with the actual number of observations available in INSTAC is given Table 3.1.

Table 3.1. Number of required and actually available T/S and oxygen profiles for 1 year in the Arctic Ocean

	Horizontal resolution	Time resolution	Number observation per year	Actual observations*
T/S profile	100	7d	72.800	33.637
	100	1d	513.190	
	300	7d	8.060	
	300	1d	56.575	
Oxygen	100	90d	5.600	3.100
	100	30d	16.800	
	300	90d	620	
	300	30d	1.860	

* *Information on actual observations stored in INSTAC have kindly been provided by Members of the INSTAC consortium. INSTAC has over the years stored in total 1.304.349 T/S profiles for the Arctic Ocean – the value used here is for 2018,*

The number of T/S profiles is far from meeting the requirements based on 100 km horizontal resolution, but is more than fine for 300 km horizontal and 1week time resolution. The problem however is that the actual observations is not equally distributed in the Arctic ocean, see Fig. 3.1, but concentrated in the Nordic Seas, Labrador Sea, Baffin Bay and north of Alaska and no observations in the central Arctic

Oxygen observations fulfil requirements for a horizontal resolution of 300 km but is below requirements for 100 km horizontal resolution, but one can question if a time resolution of 90 or 30 days really is frequent enough. The geographical bias is similar to the T/S profile situation.

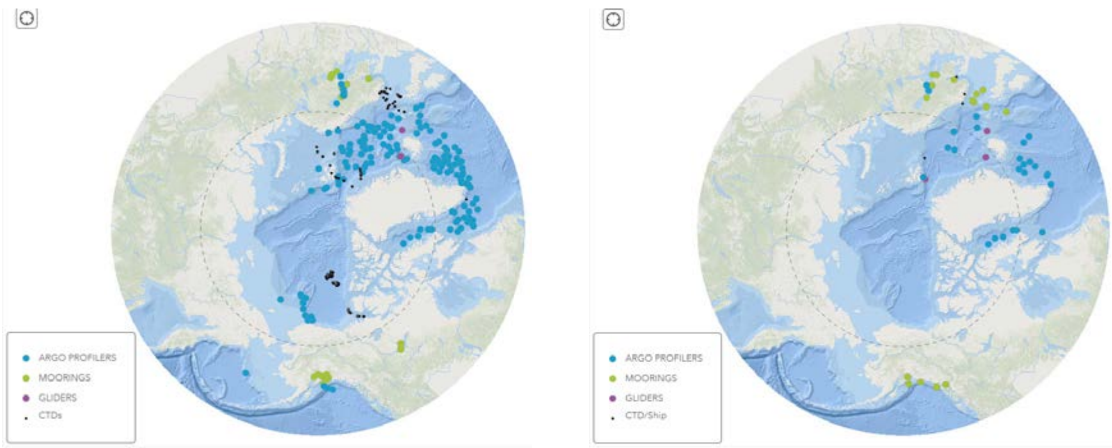

Fig. 3.1. Positions of T/S profiles (left) and Oxygen profiles (right) in the Arctic Ocean in 2018

Name	Uncertainty	Update Frequency	Timeliness	Horizontal resolution	Vertical resolution
Oxygen	Threshold:25% Breakthrough:10% Goal: 10%	Threshold: 90d Breakthrough: 30d Goal: 7d	Threshold: 7d Breakthrough: 3d Goal: 1d	Threshold: 100km Breakthrough: 50km Goal: 10k	Threshold: 100m Breakthrough: 10m Goal: 1m
Subsurface currents	Threshold:50cm/s Breakthrough: 20cm/s Goal: 10cm/s	Threshold: 3d Breakthrough: 1d Goal: 6h	Threshold: 3h Breakthrough: 2h Goal: 1h	Threshold: 100km Breakthrough: 50 km Goal: 10km	Threshold: 50m Breakthrough: 10m Goal: 1m
Subsurface salinity	Threshold: 0,1psu Breakthrough: 0,07psu Goal: 0,05psu	Threshold: 12h Breakthrough: 3h Goal: 1h	Threshold: 1d Breakthrough: 6h Goal: 3h	Threshold: 30km Breakthrough: 5km Goal: 1km	Threshold: 100m Breakthrough: 10m Goal: 1m
subsurface temperature	Threshold: 1k Breakthrough: 0,5k Goal: 0,1k	Threshold: 24d Breakthrough: 3d Goal: 1d	Threshold: 3d Breakthrough: 1d Goal: 12h	Threshold: 50km Breakthrough: 10km Goal: 2km	Threshold: 50m Breakthrough: 10m Goal: 1m
surface currents	Threshold: 20cm/s Breakthrough: 10cm/s Goal: 5cm/s	Threshold: 3d Breakthrough: 1d Goal: 12h	Threshold: 3d Breakthrough: 1d Goal: 6h	Threshold: 20km Breakthrough: 5km Goal: 1km	

Table 3.2 Example on requirements for selected oceanographic parameters

4. Summary and conclusions

The INTAROS project has been very active in establishing dialogs with stakeholders during year two and three of its project phase via organised stakeholder events, dedicated meetings with individual stakeholders, meetings with local communities in Arctic Countries and contacts to relevant stakeholders at conferences and workshops with INTAROS representations. The activities have provided the INTAROS consortium with valuable knowledge on what environmental information, products and services required by a broad spectrum of user's sector s for their operations in the Arctic region.

The overall INTAROS second stakeholder event was decided to focus on collecting detailed information on the commercial sectors requirements for information, products and services. For this purpose, a relatively detailed web-based questionnaire was formulated and invitation to respond to this survey was send to representatives from sectors such as transport, energy, tourism, fishery, insurance and coast guard (safety). Unfortunately, only 7 responded to questionnaire which is a very disappointing result. It was therefore decided to supplement with information collected and reported by other projects and organisations doing similar surveys of which a few is presented in summary in this report. This analysis revealed that several EU funded projects and other organisations has used questionnaire surveys to collect their information and the questionnaires were fairly similar in content and the number of respondents were in most cases limited although better that the INTAROS result. Since the number of commercial stakeholders in the Arctic region is fairly small it is nearby to believe that stakeholders has become "sick and tired" of replying to questionnaire with more and less the same questions. It should therefore be considered to organise collection of user requirements more centrally instead of having several projects more or less duplicating the same activity and most importantly annoying the user. This could practically be organised by pooling resources for stakeholder surveys under the EU Arctic Cluster and a cooperation with other EU DG's on this issue will be highly desirable. This could allow for a stronger and more professional collection of user requirements, which need repetition on a regular basis..

Analysing the various user surveys carried out over the past 5-10 year period it is, although the number respondent to the various surveys has not always been satisfactory, interesting to note that are not much difference between the replies obtained a few years ago and the more recent ones.

As expected, information on sea Ice (concentration, ice edge, drift thickness) and iceberg are central in the required product portfolio; but the surveys analysed in this report all displays requests for meteorological parameters (pressure, wind, temperature, visibility, precipitation, humidity, icing) and oceanographic parameters (temperature, currents and waves being the most important, but also salinity, oxygen and chlorophyll were of interest to some users). This is an important message to service providers because they need to setup a production line that focusses on three thematic area and the same has to be taken into account in the design of an Arctic Observing System.

In the preparatory phase before entering into business in the Arctic there are a need for basic information on the physical environment that can support decisions on the feasibility of the engagement taking into account security, investments, operational cost, educations etc. key products in this phase is:

- Model projections on the long-term (years) development
- Risk assessment associated with safe navigation, deployment and recovery of gear, seabed mining, hydrocarbon extraction etc
- Statistics and analysis based on existing data

For users already active in the Arctic focus is on:

- Operational Services – real-time observations and/or short-term forecasts (5-10 days)

- Ship routing
- Risk assessment

Several users pointed to the need for better navigational charts, which obviously is a request to the hydrographic community for increased activity in the Arctic region.

The surveys reveal that the users have very strong demands to resolution in space and time, quality and timeliness of the products they receive:

- Users often require a horizontal resolution of down to 100 m especially for special ice products. Such a demand can only be met by satellite observations. Very local model setups can meet such a spatial resolution but only a few of such local models exists for the Arctic region in an operational setup.
- Updating frequency for the information are generally requested to be less than one day preferably down to a few hours.
- Quality shall regularly be documented and the inclusion of uncertainty information as an integral part of the product is desirable
- For operational services it is important that every product update is available in near real-time elsewise would the strong demands for update frequency make no sense. For other types of products up to a few days are regarded as timely delivery.

For model forecast the most important forecasting period is the next 2-3 days for users operating in the Arctic area, while longer forecasting periods 7-10 days are valuable for more long-term planning purposes.

The preferred way of product delivery is via web or email presenting data in agreed format (maps, pictures, animations etc), some user also prefer to get data allowing for presentation in own software and for data analysis. Independent of the delivery method the Arctic region represents a special challenge since the communication lines has limited capacity making it difficult to send large data packages.

For national and international authorities, it is other types of information, products and services that has top priority. Essential is the long-term monitoring that form the basis for assessment of the status of the Arctic environment in general and of pollution, climate change and living resources in particular. Requirements to resolution in time and space, quality and timeliness are different than for operational services although not well-defined yet, but important is to establish long timeseries based on high quality in situ observation to analyse trends in development.

The local communities in the Arctic Region are in their daily life, so closely coupled to nature and the environment so they are therefore an important user community who requires information on:

- Long-term trends in changes of the environment that will influence their living conditions. This can be used for planning of development of their society.
- Dedicated operational products that can help them performing their daily occupation, fishery, hunting, reindeer breading etc.

An interesting aspect of the local communities/indigenous people is that they over centuries has built up a detailed knowledge of and experience with the Arctic environment. Cooperation with indigenous people is therefore an important component in the planning and design of a future Arctic Observing System partly to draw on their knowledge and experience, partly to involve them actively in observing activities.

The collected information on user requirements for information, product and services will form the basis for service providers to tailor their production system to meet these requirements. This process involves also the design of an Arctic in situ observations system that can deliver data for analysis and product generation, calibration and validation of satellite observations, assimilation into and validation of numerical models.

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Appendices

Appendix 1 INTAROS Stakeholder questionnaire

INTAROS is a EU-funded H2020 project with the objective:

> ***Develop an integrated Arctic Observation System by extending, improving and unifying existing systems in the different regions of the Arctic.***

INTAROS has a strong multidisciplinary focus with tools for integration of data from atmosphere, ocean, cryosphere and terrestrial sciences, provided by institutions in Europe, North America and Asia.

Essential to the design of a future Arctic Observation System is information on:
- User communities' requirements for products and services – existing and future needs and key priorities.
- Service providers view on the need for observational data to produce the requested products and services.

The present questionnaire will focus on collecting information on the needs for products and services from organisations planning or already operating in the Arctic

The questionnaire consists of 5 parts:
A. General information
B. Pre-operational phase – which products and services is needed by an organisation considering and preparing for entering into operational activities in the Arctic region
C. Operational phase - which products and services is needed by an organisation active in the Arctic region
D. Requirements to products and services
E. Preferred delivery of products and services

Regarding part B and C we will, if possible, appreciate your reply to both elsewise fill in the one most relevant for your present activities.

Replies to the questionnaire will be analysed and reported within the INTAROS project and made publicly available. **All replies will be treated and reported anonymously.**

Part A: General Information

1. **Respondent (it is optional to fill in this part)**
   - Name of organisation
   - Contact person
   - E-mail address

2. **What part of the Arctic region is prime focus for your plans/activity?**
   - European Arctic
   - Barents Sea
   - Kara Sea
   - Greenland/Norwegian Sea
   - Fram Strait
   - Svalbard
   - Denmark Strait
   - Cape Farewell
   - Labrador SEA/Baffin Bay

- Beaufort Sea
- Bering Sea
- Leptev Sea
- East Siberian Sea
- Northeast Passage
- Northwest Passage

3. What is your business area?

- Maritime transport
- Oil and gas
- Minerals
- Tourism, including expedition cruise tourism
- Large-scale fishery
- Small-scale fishery, hunting, or herding
- Forestry
- Wildlife
- Wind Energy
- Search and rescue
- Other

Part B: Preoperational phase

Which products and services is/was needed by your organisation when considering and preparing for entering into operational activities in the Arctic region**?**

1. Statistics and analyses based on existing data

a. Meteorology
  i. Air pressure
  ii. Wind
  iii. Temperature
  iv. Visibility
  v. Precipitation
  vi. Humidity
  vii. Icing
  viii. Other
    1. please specify

b. Ocean
  i. Temperature
  ii. Salinity
  iii. Currents
  iv. Waves
  v. Bathymetry
  vi. Oxygen
  vii. Nutrients
  viii. Chlorophyll
  ix. Other
    1. please specify

c. Sea ice incl. icebergs
  i. Concentrations
  ii. Edge

            iii. Type
            iv. Drift
            v. Thickness
            vi. Icebergs
            vii. other
                1. please specify
    d. other
        i. please specify

2. Model projections on long-term (years) future development in environmental conditions

- a. Meteorology
    - i. Air pressure
    - ii. Wind
    - iii. Temperature
    - iv. Visibility
    - v. Precipitation
    - vi. Humidity
    - vii. Icing
    - viii. Other
        - 1. please specify
- b. Ocean
    - i. Temperature
    - ii. Salinity
    - iii. Currents
    - iv. Waves
    - v. Bathymetry
    - vi. Oxygen
    - vii. Nutrients
    - viii. Chlorophyll
    - ix. other
        - 1. please specify
- c. Sea ice incl. icebergs
    - i. Concentrations
    - ii. Edge
    - iii. Type
    - iv. Drift
    - v. Thickness
    - vi. Icebergs
    - vii. other
        - 1. please specify
- d. other
    - i. please specify

3. Risk assessment

- a. Any specific requirements – please specify

4. Environmental risk assessment

- a. Any specific requirements – please specify

5. Stock assessment

- a. Any specific requirements – please specify

6. Data for own analysis

- a. Meteorology
    - i. Air pressure
    - ii. Wind
    - iii. Temperature

iv. Visibility
v. Precipitation
vi. Humidity
vii. Icing
viii. Other
1. please specify

b. Ocean
i. Temperature
ii. Salinity
iii. Currents
iv. Waves
v. Bathymetry
vi. Oxygen
vii. Nutrients
viii. Chlorophyll
ix. Other
1. please specify

c. Sea ice incl. icebergs
i. Concentrations
ii. Edge
iii. Type
iv. Drift
v. Thickness
vi. Icebergs
vii. other

d. Other
i. please specify

7. Other Products and services
a. Please specify

Part D. Operational phase

Which products and services do you need when active in the Arctic region?

1) Operational services – near real-time observations and/or short term (5-10 days) forecasts

a) Meteorology
i) Air pressure
ii) Wind
iii) Temperature
iv) Visibility
v) Precipitation
vi) Humidity
vii) Icing
viii) Other
(1) please specify

b) Ocean
i) Temperature
ii) Salinity
iii) Currents
iv) Waves
v) Bathymetry

vi) Oxygen
vii) Nutrients
viii) Chlorophyll
ix) Other
(1) please specify

c) Sea ice incl. icebergs
i) Concentrations
ii) Edge
iii) Type
iv) Drift
v) Thickness
vi) Icebergs
vii) Other
(1) please specify

2) Ship Routing Service
a) Any specific requirements – please specify

3) Risk assessment
a) Any specific requirements – please specify

4) Environmental risk assessment
a) Any specific requirements – please specify

5) Stock assessment
a) Any specific requirements – please specify

6) Data for own analysis
a) Meteorology
i) Air pressure
ii) Wind
iii) Temperature
iv) Visibility
v) Precipitation
vi) Humidity
vii) Icing
viii) Other
(1) please specify

b) Ocean
i) Temperature
ii) Salinity
iii) Currents
iv) Waves
v) Bathymetry
vi) Oxygen
vii) Nutrients
viii) Chlorophyll
ix) Other
(1) please specify

c) Sea ice incl. icebergs
i) Concentrations
ii) Edge
iii) Type
iv) Drift
v) Thickness
vi) Icebergs
vii) Other

(1) please specify
d) Other
(1) please specify

7) Other product and services

a) Please specify

Part E. Requirements to products and services

Please indicate your demands on:
- spatial details (resolution in space)
- details in time/how often (resolution in time)
- timely delivery - delay compared to real time (timeliness)
- quality documentation

- Resolution in space
  - 100 metres
  - 1 kilometre
  - 10 kilometres
  - 25 Kilometres
  - 100 Kilometres
  - More
    - Please specify
- Resolution in time
  - 1 hour
  - 3 hours
  - 6 hours
  - 12 hours
  - 24 hours
  - Other
    - Please specify
- Timeliness of product delivery
  - Near real time
  - 6 hours
  - 12 hours
  - 24 hours
  - 1 week
  - 1 month
  - Other
    - Please specify
- Quality
  - Quality shall be documented regularly
  - Products shall include uncertainty information
- Other
  - Please specify

Preferred delivery of products and services?

How do you prefer information's delivered?

- Web based presentation in agreed format

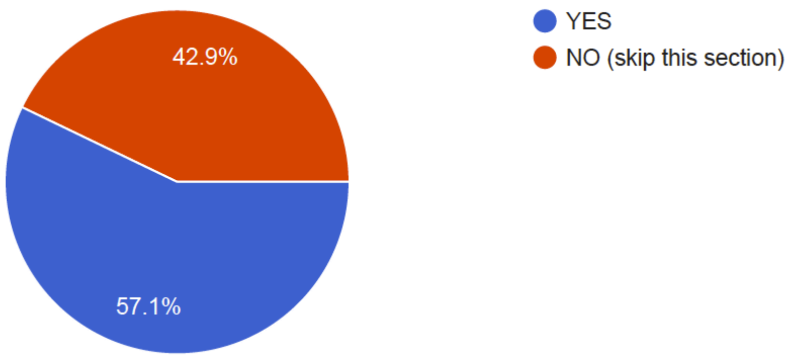
- E-mail
- Data files in format suited to own presentation software
- Report
- Text bulletins
- Supplementary personal briefings

Appendix 2 Results from the INTAROS Stakeholder survey

Preoperational phase

Is your organization considering and preparing for entering into operational activities in the Arctic Region?

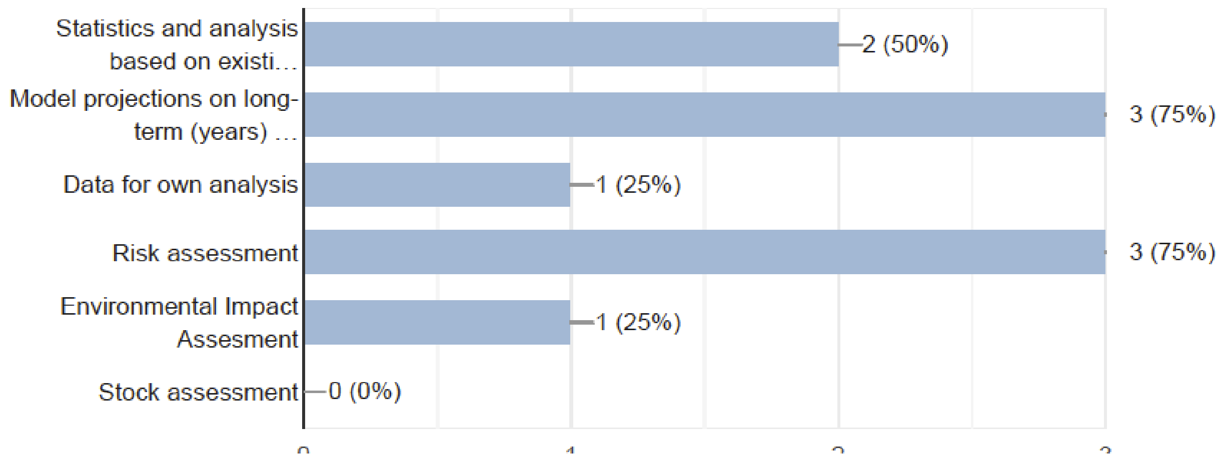
7 responses



Four out of seven respondents are interested in pre-operational products.

Product groups

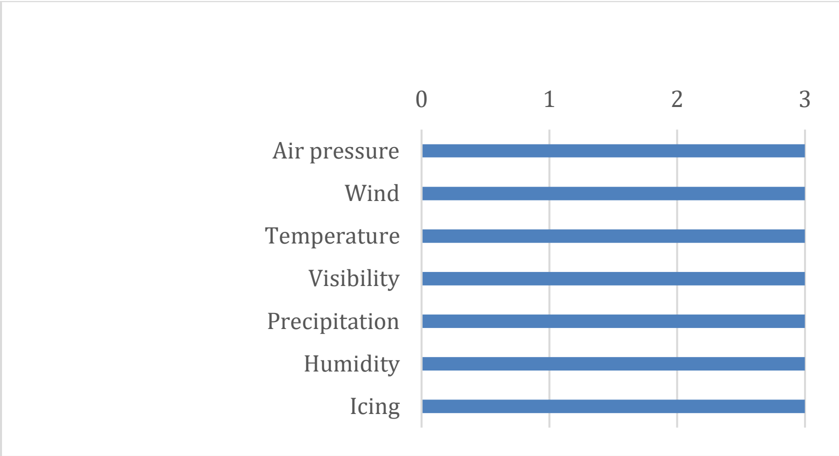
4 responses



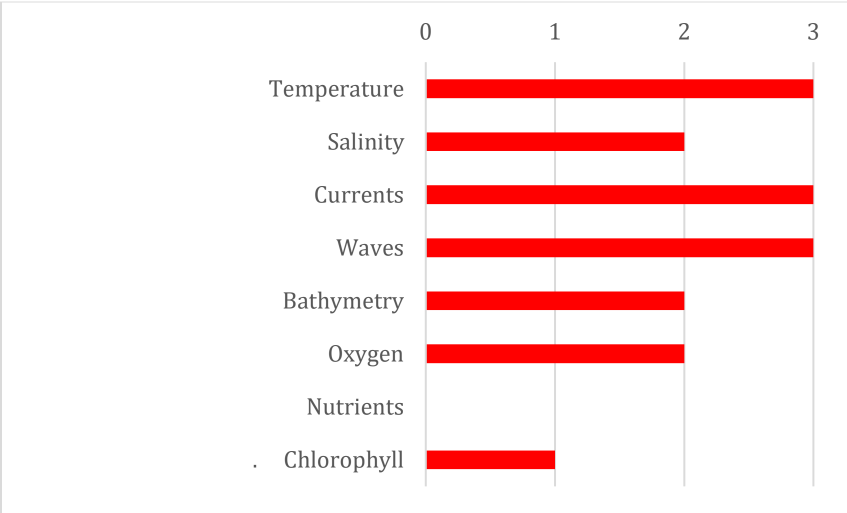
Parameters requested for "Statistics and analysis's based on existing data"

Respondents: 3

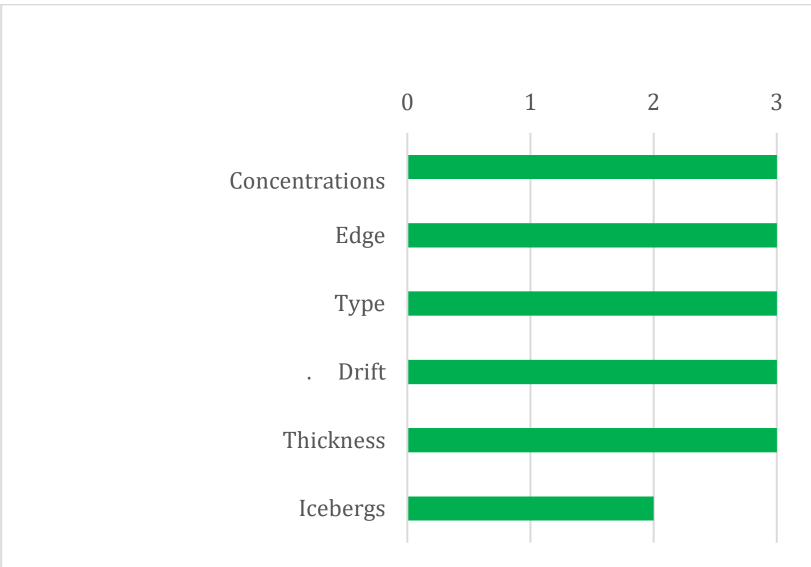
Meteorology



Oceanography



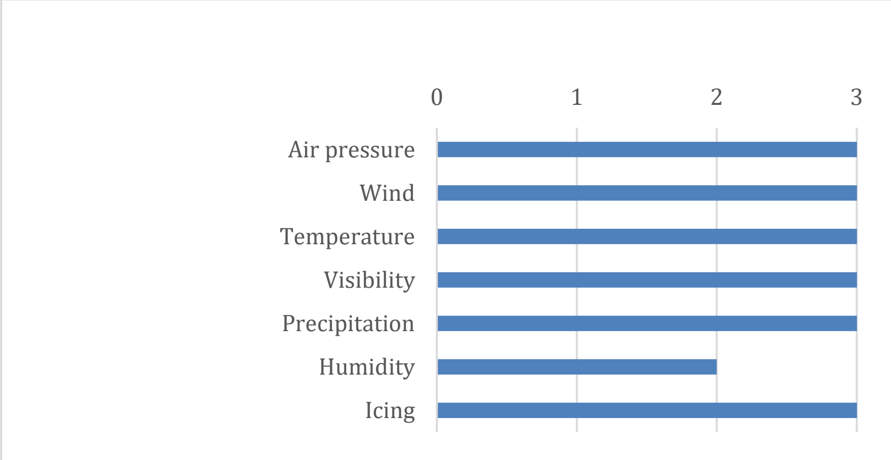
Sea Ice including Icebergs



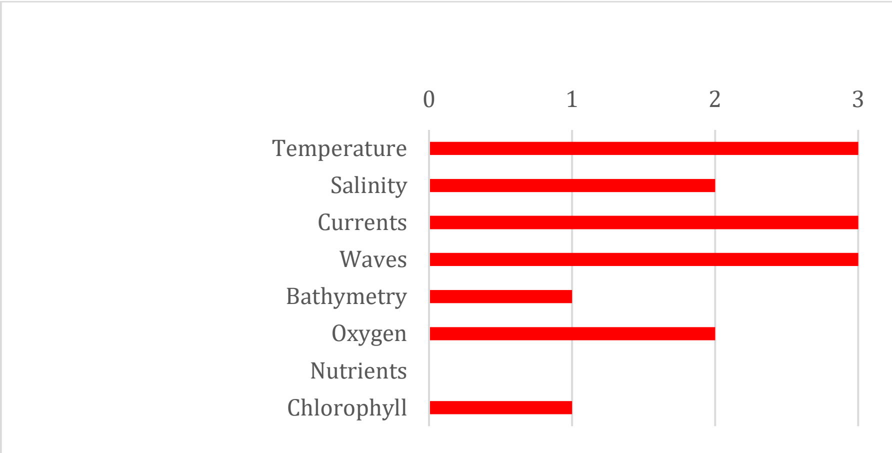
Parameters needed for "Model projections on long-term (years) future development in environmental conditions

Respondents: 3

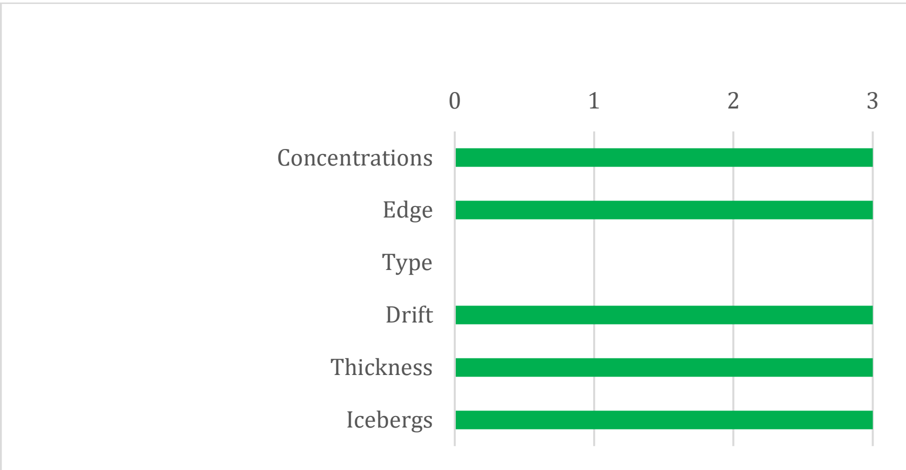
Meteorology:



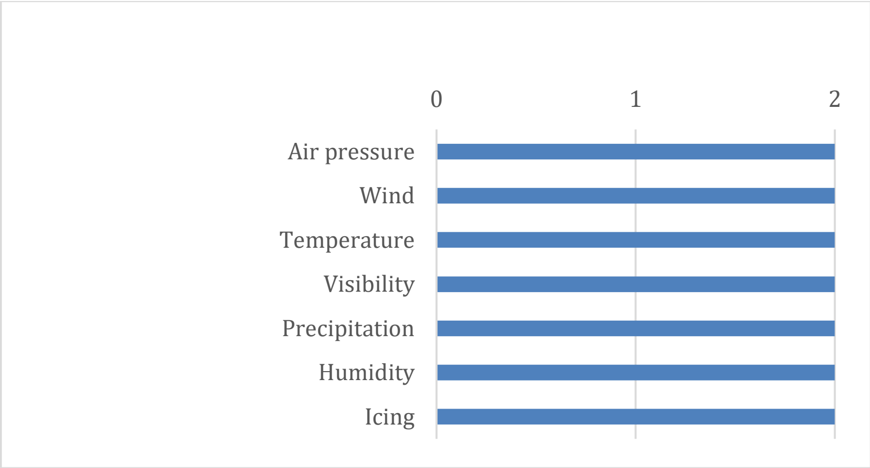
Oceanography:



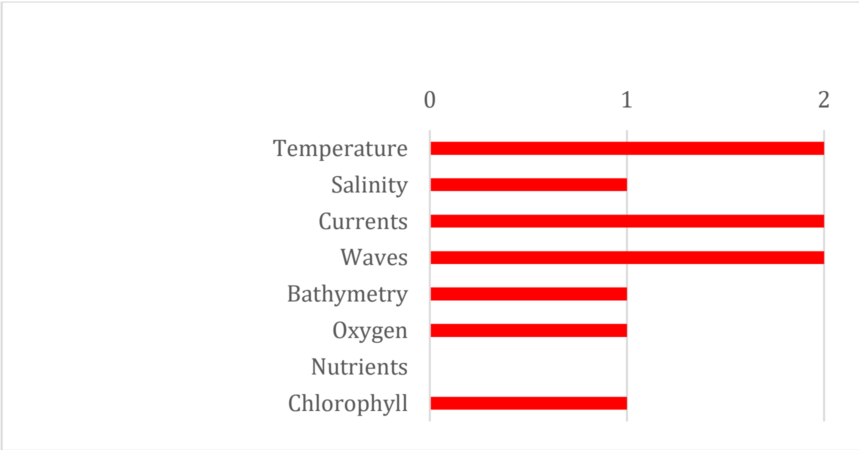
Sea ice including Icebergs



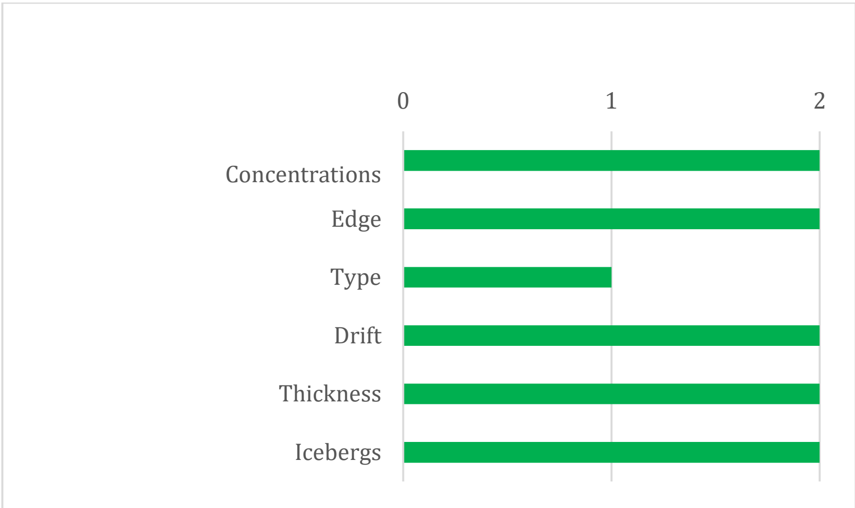
Parameters needed for "data for own analysis"
Respondents: 2
Meteorology



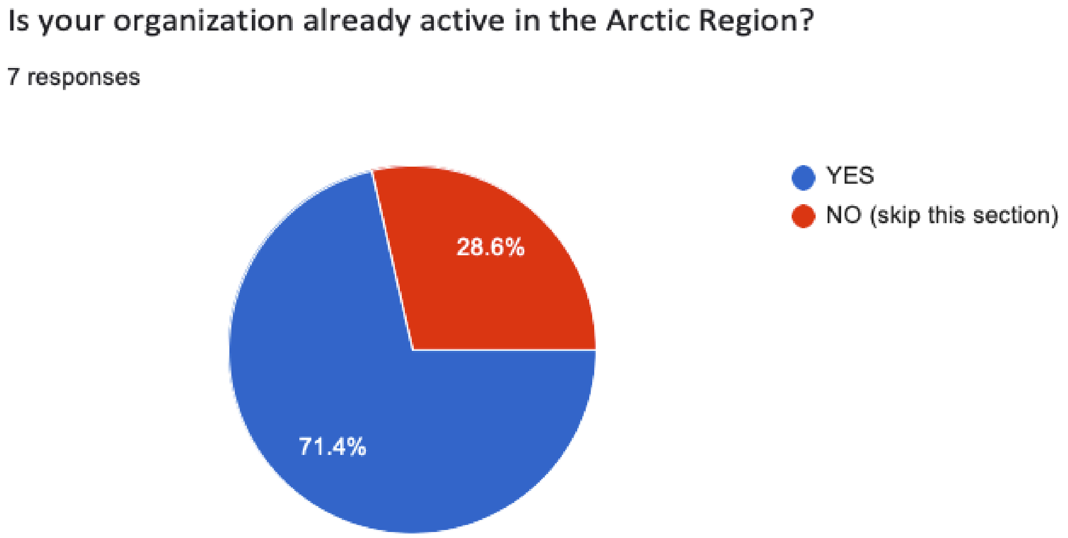
Oceanography



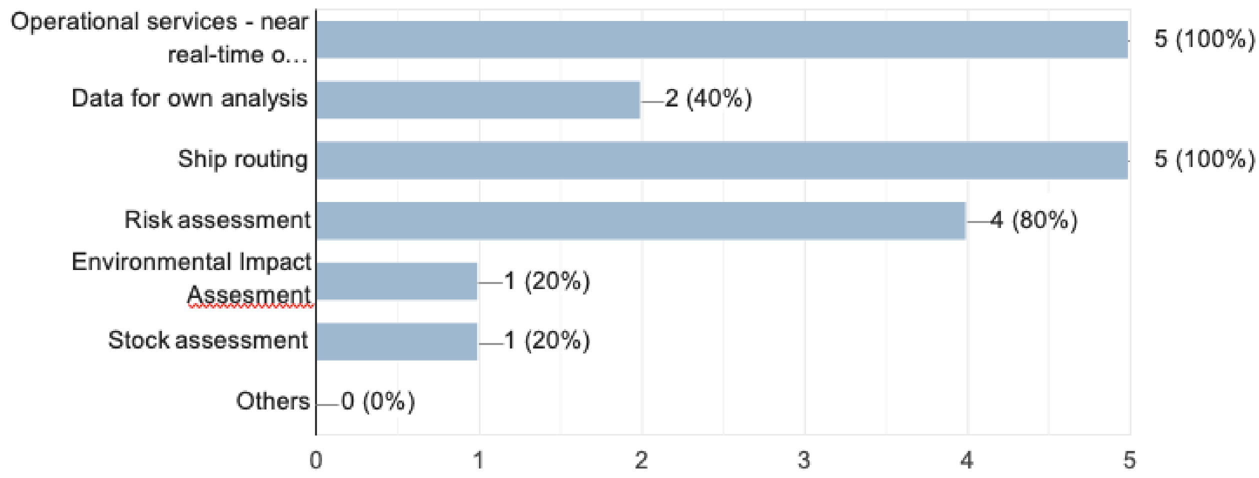
Sea ice



Operational phase

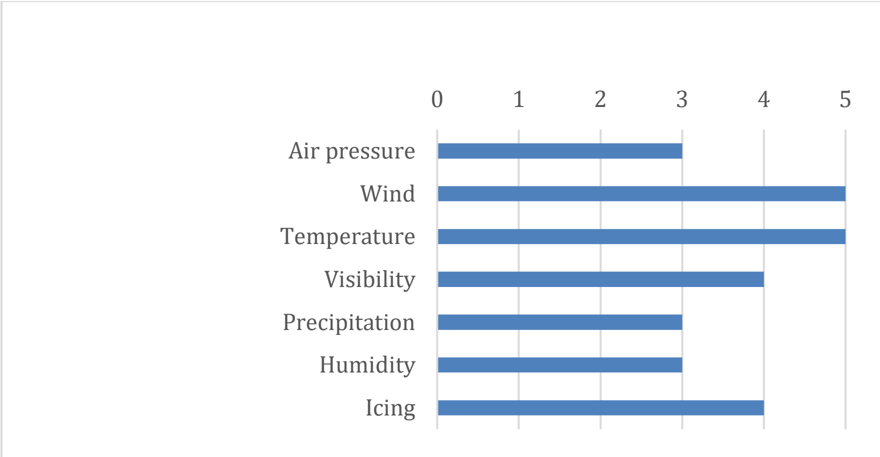


Product groups
5 respondents

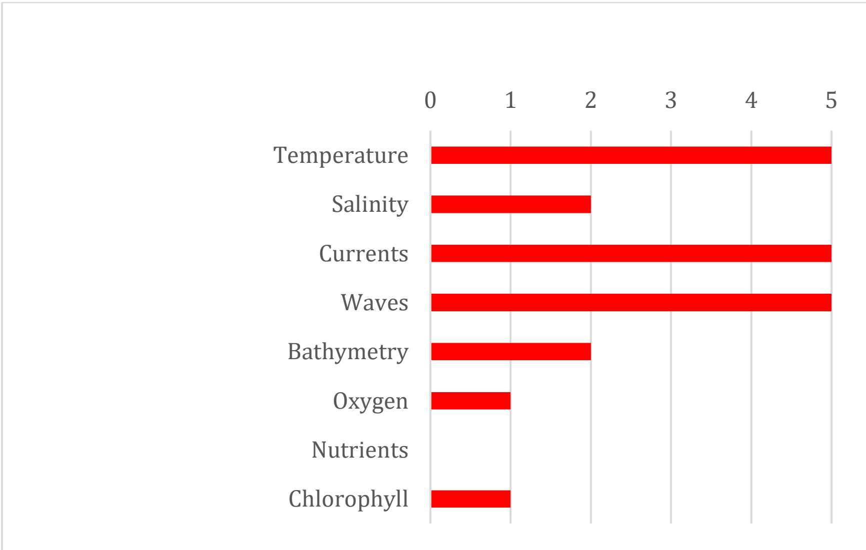


Parameters needed for "Operational services- near real-time observations and/or short term (5-10 days) forecasts (5 respondents)

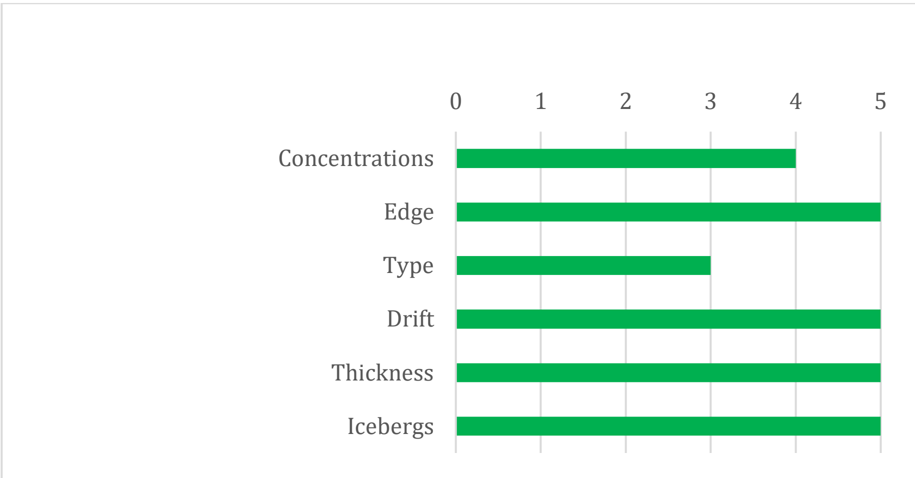
Meteorology



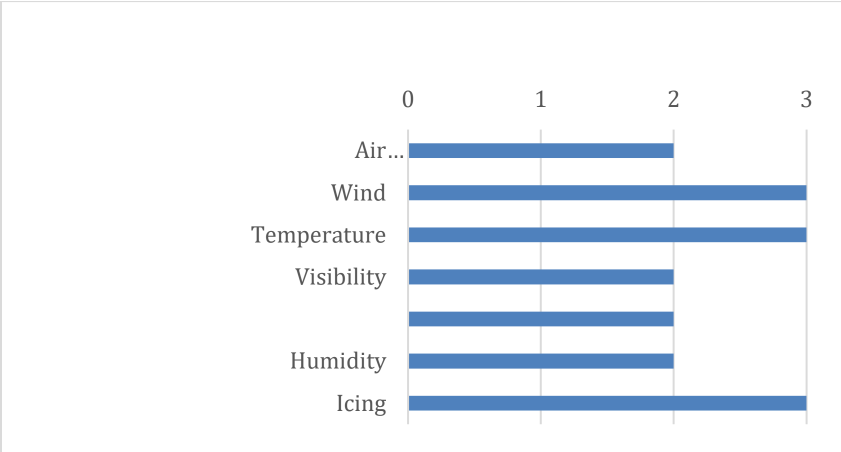
Oceanography



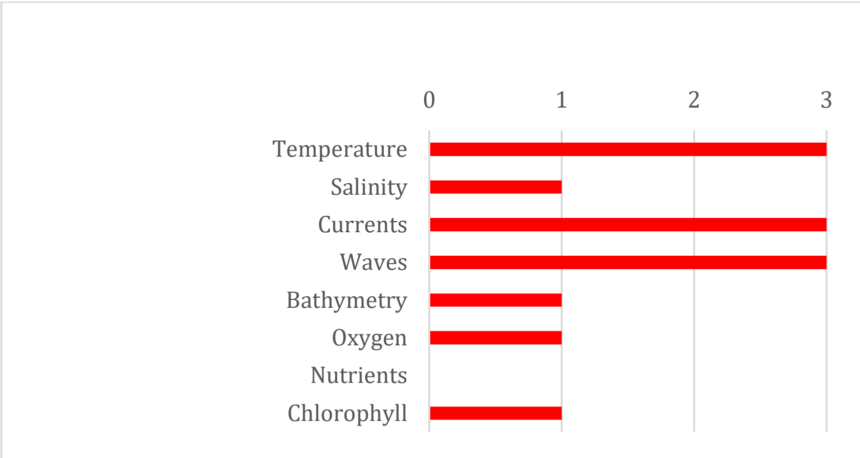
Sea Ice



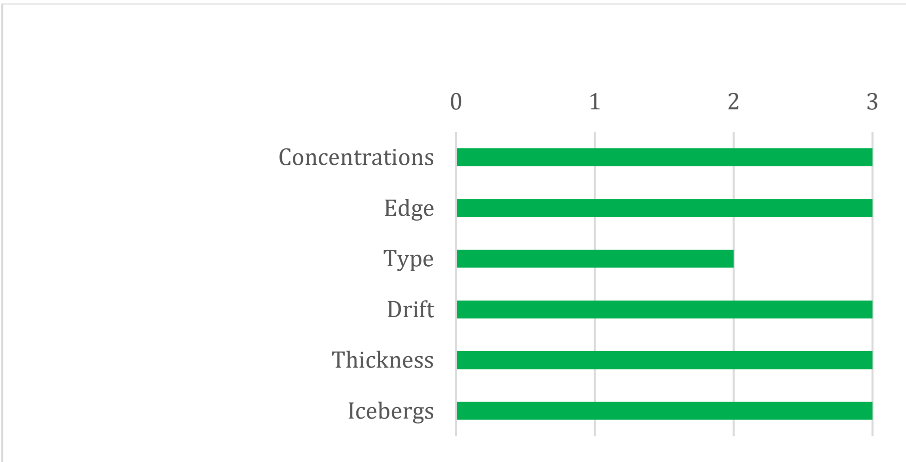
Parameters needed for "Data for own analysis"
3 respondents
Meteorology



Oceanography



Sea ice



Appendix 3. Results from SIDARUS Stakeholder survey

The numbers give the amount of replies out of 18.

Parameter	Product	Response		
		Marine Safety Response	Marine and Costal environment	Climate and seasonal forecasting
Concentration	Percentage of cover	7	3	2
Concentration	Coverage in classes (e.g open Drift Ice (4/10-7/10). Very closed drift ice (9/10-10/10)	9	1	
Concentration	Ice or No Ice	6	1	
Edge	Detailed ice edge line	7	3	1
Edge	Simplified ice edge line (e.g 10-20 longitude/latitude coordinates)	2	0	
Type	WMO Ice Classes	7	2	2
Type	Simplified ice edge line (e.g 10-20 longitude/latitude coordinates)	7	1	
Drift	Low resolution (10 km)	5	1	2
Drift	High resolution (1 km)	11	2	
Deformation	Ridging	7	1	2
Deformation	Leads and Polynyas	8	2	2
Deformation	Floe Size	6	2	2
Thickness	Actual values	7	1	1
Thickness	Thickness in classes	6	0	
Thickness	Mean Average Thickness	6	1	1
Thickness	Modal Average Thickness	3	0	
Icebergs	Occurrence	10	0	
Icebergs	Size	6	0	
Icebergs	Drift	8	0	
Icebergs	Shape (Normal/Tabular)	4	0	
Other	Snow Cover	4	2	2
Other	Water Cover on ice	3	1	2
Other	Surface Temperature (Freezing/Melting)	7	1	1
	Number of respondents	13	3	2

Table A3.1: Need for sea ice parameters

It is worth noting that all segments need information of sea ice concentration, edge, type, deformation and thickness while ice berg is only important for the Marin Safety users

		Response		
Parameters	**Products**	**Marine Safety Responce**	**Marine and Costal environment**	**Climate and seasonal forecasting**
Meteocean information	Air pressure	7	2	
Meteocean information	Wind	13	2	1
Meteocean information	Others	2	1	1 (Air temp.)
Oceanographic information	SST	2	2	2
Oceanographic information	Current	10	1	2
Oceanographic information	Chlorophyll	1	1	1
Oceanographic information	Bathymetry	1	1	1
	Number of respondents	13	3	2

Table A3.2: Meteocean and oceanographic parameters requested

	Response		
Update frequency	**Marine Safety**	**Marine and Costal environment**	**Climate and seasonal forecasting**
As often as possible	10		
Daily	7	2	1
Weekly	1	1	
Monthly	1	1	1
Annually			
On request for historical data	3	2	

Table A3.3 Required update frequency of sea ice information

	Response		
Spatial resolution	**Marine Safety**	**Marine and Costal environment**	**Climate and seasonal forecasting**
100m	8	2	
1 km	8	1	
10 km	4	1	2
25 km	1	1	1

Table A3.4: Required spatial resolution

	Response		
Time period for Ice forecasts	**Marine Safety Responce**	**Marine and Costal environment**	**Climate and seasonal forecasting**
Not applicable		3	1
2-3 days	11		
Week	6		
month	4		
3 months	6		1
1 year	1		1

Table A3.5. Required time period for sea ice forecasts

	Response		
Delivery method	**Marine Safety Responce**	**Marine and Costal environment**	**Climate and seasonal forecasting**
Download from web	10	3	2
E-mail	8	2	
Electronic Navigation chart	9		
Navtex	2		
AIS	7		

Table A3.6. Preferred delivering mechanism

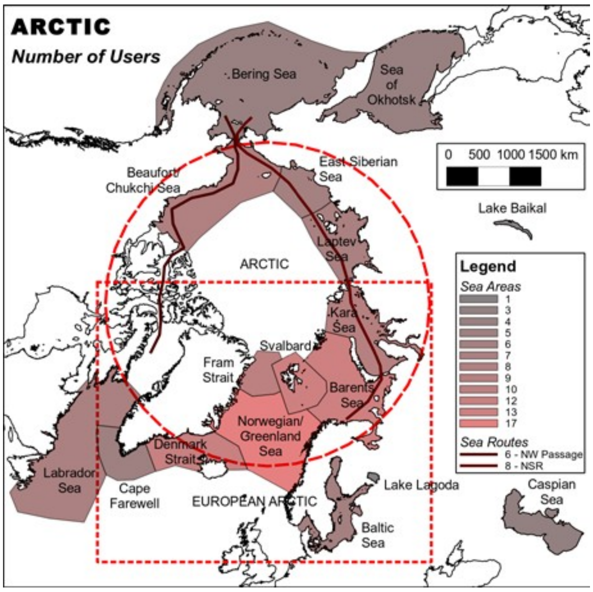
	Response		
Data format	**Marine Safety**	**Marine and Costal environment**	**Climate and seasonal forecasting**
JPEG/PNG/PDF	10		
GeoTiff	4	1	
JPEG2000	1		
GeoPDF	0		
NetCDF	1	1	2
Text (ASCII)	1		
Shapefile	4	3	
S-100	4		

Table A3.7. Preferred product data format

Appendix 4 Results from ACCESS user survey

Geographical Areas

Maps showing the geographical areas and sea routes of interest to the users in the Arctic are shown in Fig. A4.1



A4.1: Map showing geographical areas of sea ice information provision and numbers of interested users.

Geographical Area	*Oil/ Gas*	*Research*	*Shipping*	*Other*	*Total*
Baltic Sea	1	3	2		6
Barents Sea	4	3	4	2	13
Kara Sea	4	3	2		9
Greenland/Norwegian Sea	4	5	5	3	17
Fram Strait	3	4	3		10
Svalbard	2	4	4	3	13
Denmark Strait	3	4	3	2	12
Cape Farewell	1	1	2	1	5
Laptev Sea	2	3	2		7
East Siberian Sea	1	3	1	1	6

Table A4.1. User sector breakdown for different Arctic sea areas.

Respondents were interested in information covering shipping routes. Of these 8 (61.54%) were Northern Sea Route. 6 (46.15%) North-West Passage, and 4 (30.77%) both. In addition, 2 (15.38%) were interested in ice information provision (icebergs) around Cape Horn

Sea Route	*Oil/Gas*	*Research*	*Shipping*	*Other*	*Total*
Northern Sea Route	1	1	5	1	8
North-West Passage	1	2	2	1	6
Cape Horn	0	1	0	1	2

Table A4.2. Summary of the shipping routes of interest, and this is also shown in Figure 4-2.

Types of Sea Ice Information Required

The questionnaire asked the users about their usage of the different sea ice parameters typically found on ice charts, including sea ice concentration, mapping of the ice edge, sea ice type (stage of development), sea ice drift, ice deformation, sea ice thickness, icebergs, or whether they had any other parameters they would like to see on ice charts.

Ice Concentration

All respondent organisations were interested in ice concentration. Of these most (15 or 71.43%) wanted percentage ice concentration values, 12 (57.14%) wanted ice concentration classes such as Open Drift Ice (4/10 – 7/10), Very Close Drift Ice (9/10 – 10/10), etc., and 8 (38.1%) would also be satisfied with just simple ice/no ice coverage. The interest between user sectors is shown in A4.3

	Oil/Gas	*Research*	*Shipping*	*Other*	*Total*
Percentage	4	6	4	1	15
Classes	3	4	3	2	12
Ice/No ice	3	2	2	1	8

A4.3. Ice concentration requirements.

Mapping of the Ice Edge

An alternative to ice concentration mapping for users who want to avoid the ice, rather than go into it, is the mapping of the ice edge. Table A4.4 shows that the clear preference was for as much detail as possible, with 14 (66.67%) wanting a detailed ice edge, and 2 (9.52%) just a simplified ice edge, e.g. METAREA-XIX style.

	Oil/Gas	*Research*	*Shipping*	*Other*	*Total*
Detailed ice edge	4	5	4	1	14
Simplified ice edge	2	0	0	0	2

Table A4.4. Ice edge requirements.

Sea Ice Type (Stage of Development)

Type of ice can either be represented as the standard WMO ice classes based on stage of development, that include different sub-types of new or first-year ice, or in a simplified scheme such as 3-class; new ice, first year, and multi-year ice. 17 (80.95%) of users found ice type information useful. The level of detail provided did not matter so much, with 14 (66.67%) wanting WMO ice type classes and 11 (52.38%) wanting simple ice type classification.

	Oil/Gas	*Research*	*Shipping*	*Other*	*Total*
WMO ice classes	4	4	5	1	14
Simplified ice class	4	2	4	1	11

Table A4.5. Sea ice type (stage of development) requirements.

Sea Ice Drift

18 (85.71%) of users wanted ice drift information. Although low resolution products, based on passive microwave and scatterometer, are routinely available daily, only 5 (23.81%) wanted data of this type. Most (16 or 76.19%) wanted the high-resolution ice drift products derived from Synthetic Aperture Radar (SAR). These are available only for those periods when the satellite is acquiring data. The shipping user sectors clearly preferred greater resolution.

	Oil/Gas	*Research*	*Shipping*	*Other*	*Total*
Low resolution	3	2	0	0	5
High resolution	4	5	4	3	16

A4.6: Ice drift product requirements.

Deformation of Ice

15 (71.43%) of users wanted information on where ice deformation, such as floe size, ridging, and lead/polynya development, was occurring. Information on leads and polynyas was slightly more important than the other two parameters. 12 (57.14%) of users wanted information on leads/polynyas, and 10 (47.62%) each for ridging and floesize.

	Oil/Gas	*Research*	*Shipping*	*Other*	*Total*
Ridging	4	3	2	1	10
Leads and polynyas	4	5	1	2	12
Floe size	4	4	0	2	10

A4.7. Ice deformation information requirements.

Sea Ice Thickness (Stage of Development)

Sea ice thickness information was required by 18 (85.71%) of users. The preference was for actual values to be provided (12 or 57.14%) of users. However, this was closely followed by ice thickness in classes, such as those of the WMO stage of development, with 10 (47.62%). Mean average and modal average values scored 7 (33.33%) and 4 (19.05%) respectively.

	Oil/ Gas	*Research*	*Shipping*	*Other*	*Total*
Actual values	4	4	4	0	12
Thickness classes	4	3	1	2	10
Mean average	3	2	2	0	7
Modal average	3	1	0	0	4

Table A4.8. Sea ice thickness requirements.

Icebergs

14 (66.67%) of users wanted iceberg information. Occurrence and drift were required by 12 (57.14%) each. Size and shape were slightly lower at 9 (42.86%) and 7 (33.33%) of users.

	Oil/Gas	*Research*	*Shipping*	*Other*	*Total*
Occurrence	4	1	5	2	12
Size	4	1	3	1	9
Drift	4	1	6	1	12
Shape	3	1	2	1	7

Table A4.9. Iceberg information requirements.

Other parameters

The users were asked about their requirements for other parameters associated with sea ice including snow cover, surface temperature, and area with water cover (melt ponds). 16 (76.19%) said one or more of these parameters was of interest. Of these the surface temperature was found to be clearly the most important, with 14 (66.67%). This was followed by sow cover with 10 (47.62%) and finally water cover with 6 (28.57%).

	Oil/Gas	*Research*	*Shipping*	*Other*	*Total*
Snow cover	3	4	2	1	10
Surface temperature	4	4	4	2	14
Water cover	2	2	2	0	6

Table A4.10. Other parameters.

Conclusions on sea ice parameters

The high level of interest in each parameter type, over two thirds (66.67%) for each, shows that the users are interested in obtaining as much information about sea ice, in as high a level of detail as possible. Ice concentration in percentage values, and the WMO stage of development for ice type are widely seen as being correct and the best way of presenting that information. However, more work needs to be done to meet the users expectations for high resolution ice drift and obtaining actual ice thickness values on a routine basis. A summary table of the parameters in order of respondent usefulness is shown below.

Parameter	*Number of users*	*%*	*Level of detail*
Concentration	21	100.00	Percentage
Sea Ice Drift	18	85.71	High resolution
Sea Ice Thickness	18	85.71	Actual values
Sea Ice Type	17	80.95	WMO ice classes
Ice Edge	16	76.19	Detailed
Other	16	76.19	Surface temperature
Deformation	15	71.43	Leads and polynyas
Icebergs	14	66.67	Occurrence/Drift

Table A4.11: Summary of sea ice parameters.

Types of Metocean Information Required

The users were asked about different types of meteorological and oceanographic (metocean) information required. This preceded a more detailed questionnaire appended by the WMO to the ice information questionnaire.

Meteorology

Nearly all respondents (20 or 95.24%) required meteorological information. Of these all wanted information on winds whilst 10 (47.62%) also wanted information on atmospheric air pressure. 4 (19.05%) identified other parameters of interest, including air temperature, visibility, and surface fluxes.

	Oil/Gas	Research	Shipping	Other	Total
Air pressure	3	2	4	1	10
Winds	4	6	7	3	20
Others	2	2	0	0	4

Table A4.12. Meteorological parameters.

Oceanography

Nearly all respondents (19 or 90.48%) required oceanographic information. Clearly the most relevant was information on currents with 17 (80.95%). Other parameters were not popular, with 8 (38.1%) wanting sea surface temperature (SST), 5 (23.81%) with bathymetry, and 4 (19.05%) chlorophyll. 3 (14.29%) identified other parameters including surface fluxes, salinity, tides, and waves. Ocean and tidal currents was the clear wish of the shipping community, with all 7 respondent organisations requesting it.

	Oil/Gas	Research	Shipping	Other	Total
SST	2	5	1	0	8
Currents	3	4	7	3	17
Chlorophyll	0	4	0	0	4
Bathymetry	1	4	0	0	5
Others	1	2	0	0	3

Table A4.13. Oceanographic parameters.

Update Frequency and Level of Detail (Spatial Resolution)

The respondents were asked how often they required ice information to be updated.
"*As often as possible*" and "*on request*" represented the largest group, with 12+5 (57.14+23.81%) of respondents. Daily was next most requested with 12 (57.14%). There were no requests for annually updated products

	Oil/Gas	Research	Shipping	Other	Total
As often as possible	3	2	5	2	12
On request	3	2	0	0	5
Daily	1	3	6	2	12
Weekly	1	2	0	0	3
Monthly	1	2	0	0	3
Annually	0	0	0	0	0

A4.14. Update frequency.

The participants were asked about the level of detail required in ice information products. The general answer was "*as much detail as possible*".

	Oil/ Gas	Research	Shipping	Other	Total
100 metres	4	4	3	1	12
1 kilometre	2	3	5	3	13
10 kilometres	1	3	4	0	8
25 kilometres	1	2	2	0	5

Table A4.15. Spatial Resolution.

Length of Forecasts

The respondents were asked two questions in the questionnaire relating to length of forecast. The first of these, "*What time period of tactical and operational ice forecast (short-term) information is most useful?*" is for short- to medium- range (tactical and operational) forecasts, up to one year. The second, "*Do you have a requirement for long-term predictions, i.e. on the effect of climate change on sea ice?*", is more specific to the ACCESS project and covers the strategic forecasts produced by some organisations.

Most users (14 or 66.67%) require short-term (2-3 day) forecasts for tactical purposes Some require slightly longer tactical forecasts of one-week duration (7 or 33.33%). Operational forecasts of one month or a season (3 months) are required by 6 (28.57%) and 7 (33.33%) respectively.

	Oil/ Gas	*Research*	*Shipping*	*Other*	*Total*
Not applicable	0	3	0	0	3
2-3 days	3	3	6	2	14
1 week	4	0	3	0	7
1 month	2	1	3	0	6
3 months (seasonal)	3	1	2	1	7
1 year	1	0	0	0	1

Table A4.16. Tactical and operational forecasts.

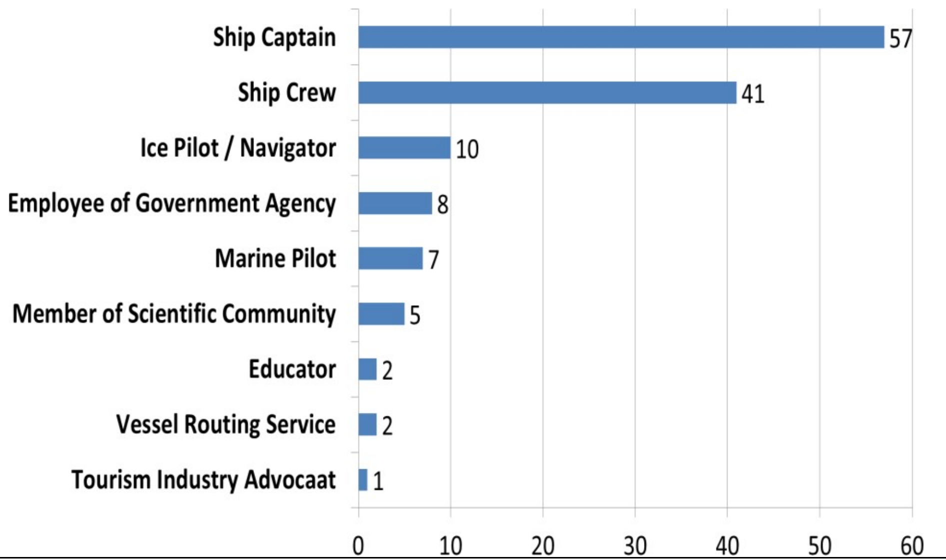
Table below shows the user requirement for strategic forecasts. 10 (47.62%) organisations wanted strategic forecasts of which 8 (38.1%) wanted them in duration of years, and 7 (33.33%) wanted decades. 5 (23.81%) wanted both.

	Oil/ Gas	Research	Shipping	Other	Total
Not applicable	1	4	4	1	10
Years	1	3	3	1	8
Decades	2	2	1	2	7

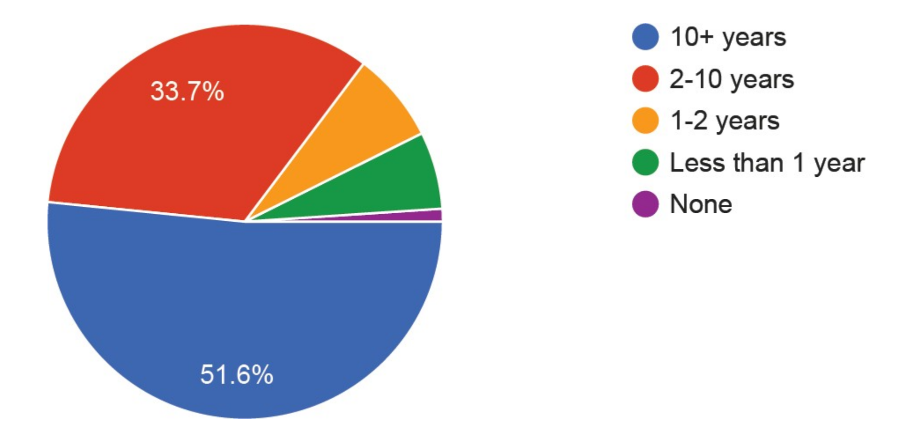
Table A4.17. Strategic forecasts.

Appendix 5. International Ice Charting Working Group Mariners survey

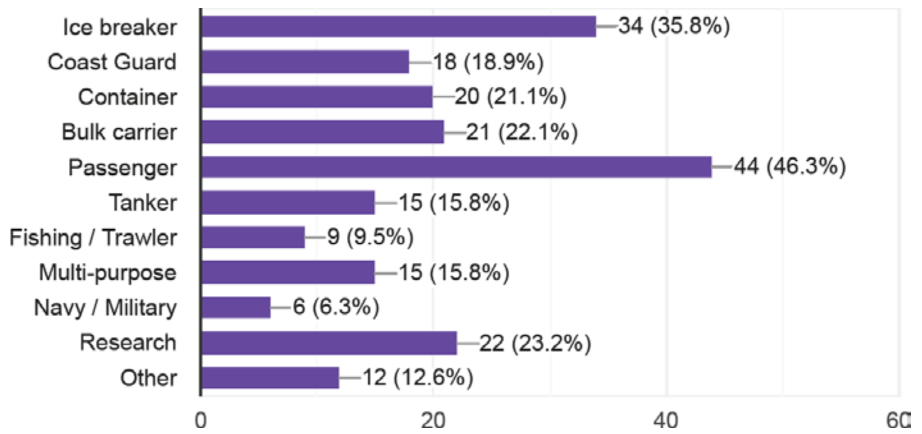
. In what employment capacity have you served in or near ice-covered waters?



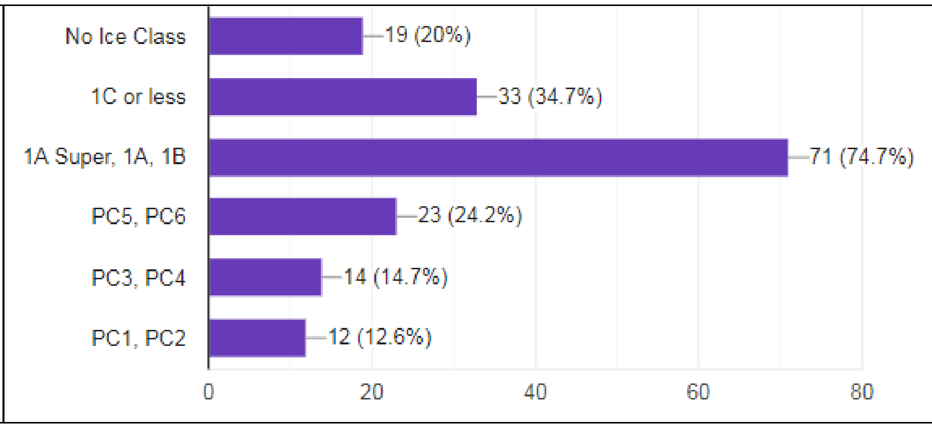
2. How many years of navigation experience do you have in or near ice-covered waters?



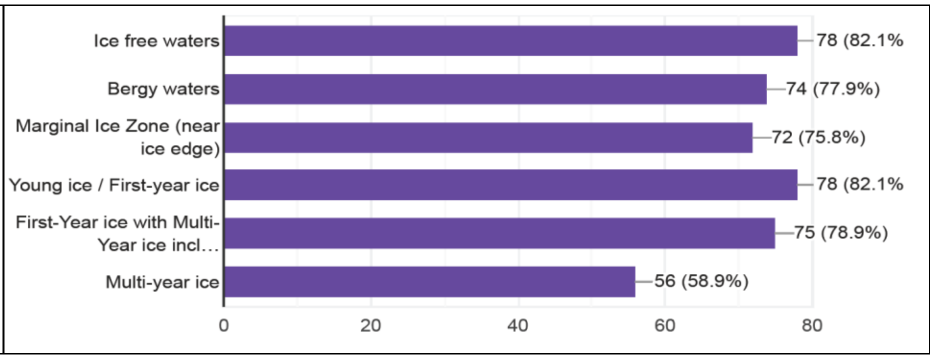
3. What type(s) of vessel have you served on in or near ice-covered waters?



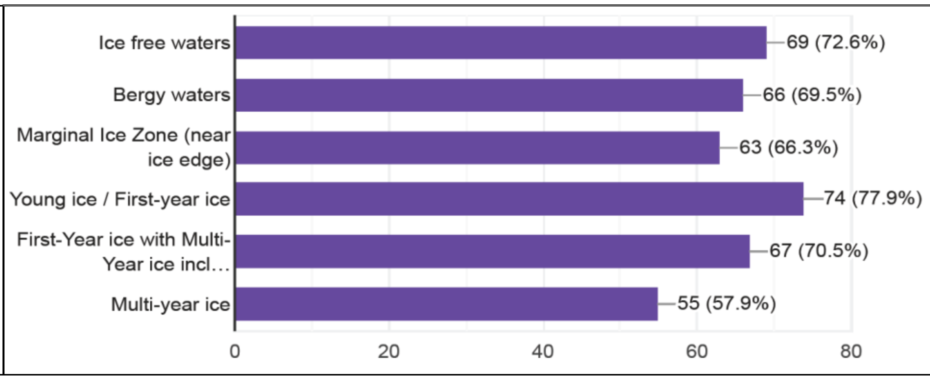
4. What is the vessel ice classes (equivalents to to the Swedish-Finnish ice classes) you served on in or near ice-covered waters? (select all that apply)



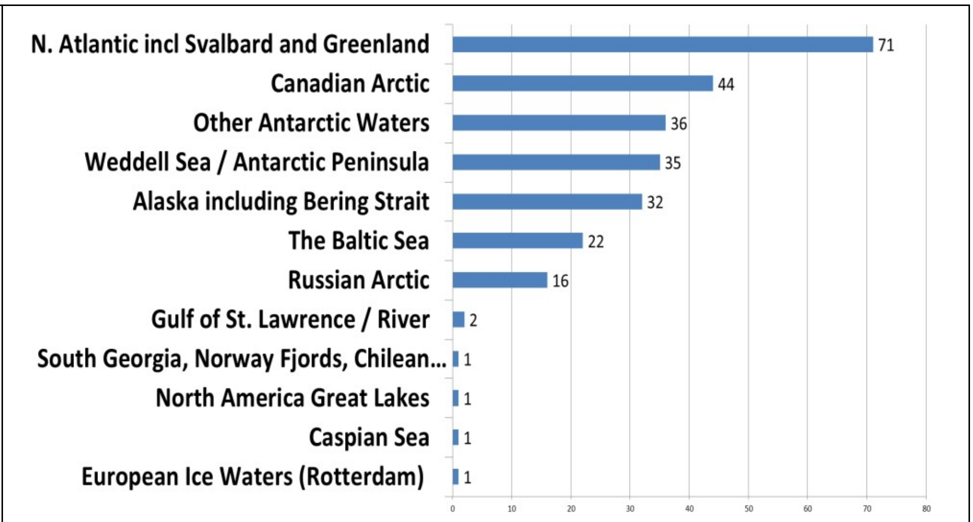
5. In what ice regime(s) do you have navigation experience? (select all that apply)



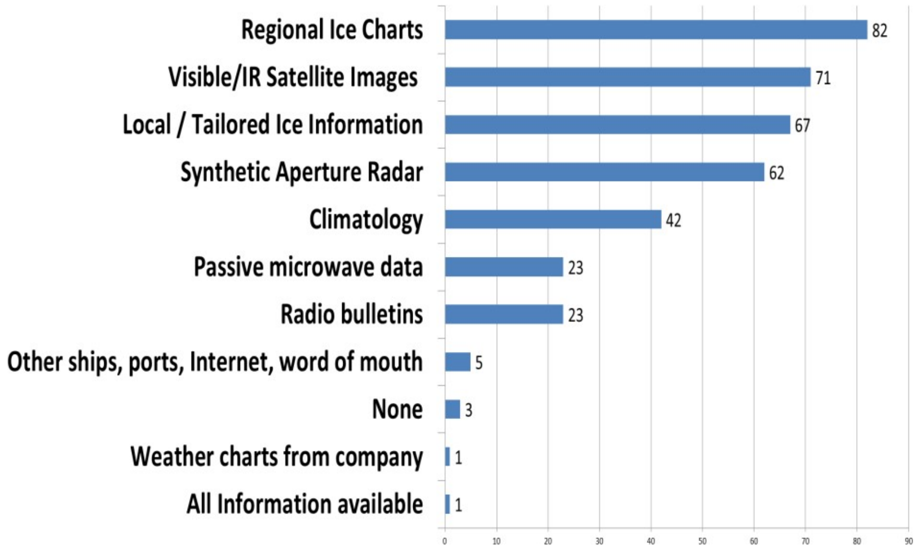
6. What ice regime(s) do you expect to or would like to navigate within in the future? (select all that apply)



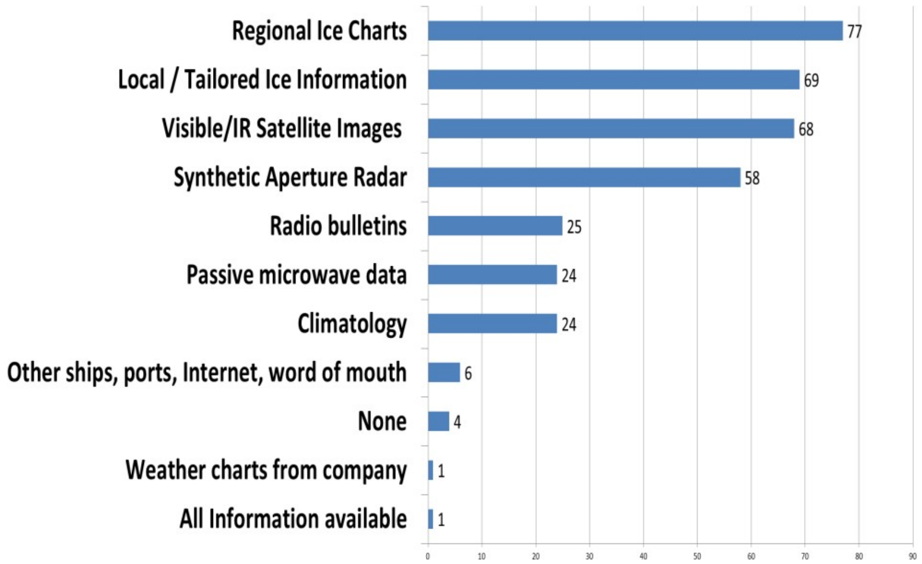
7. What geographical region(s) do you navigate in and use ice information? (select all that apply)



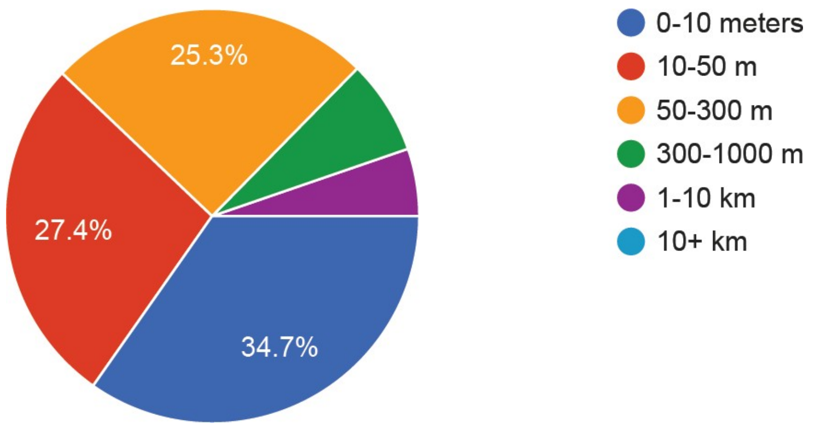
8. Which categories of ice information do use for route planning and risk assessment? (select all that apply)



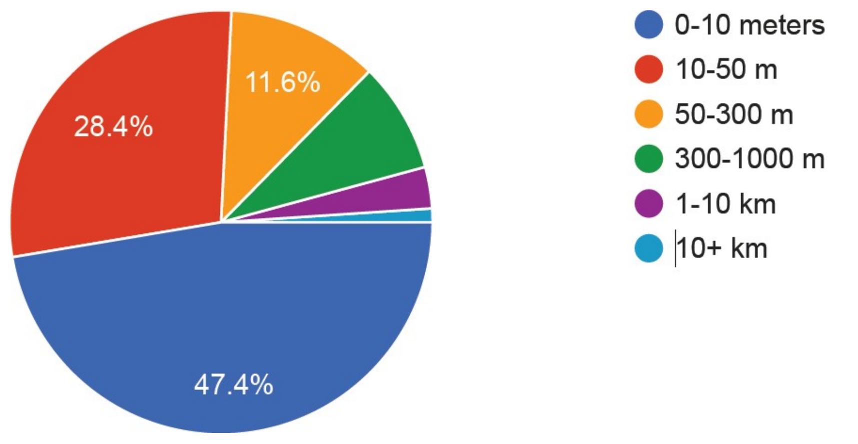
9. Which categories of ice information do you use for navigation? (select all that apply)



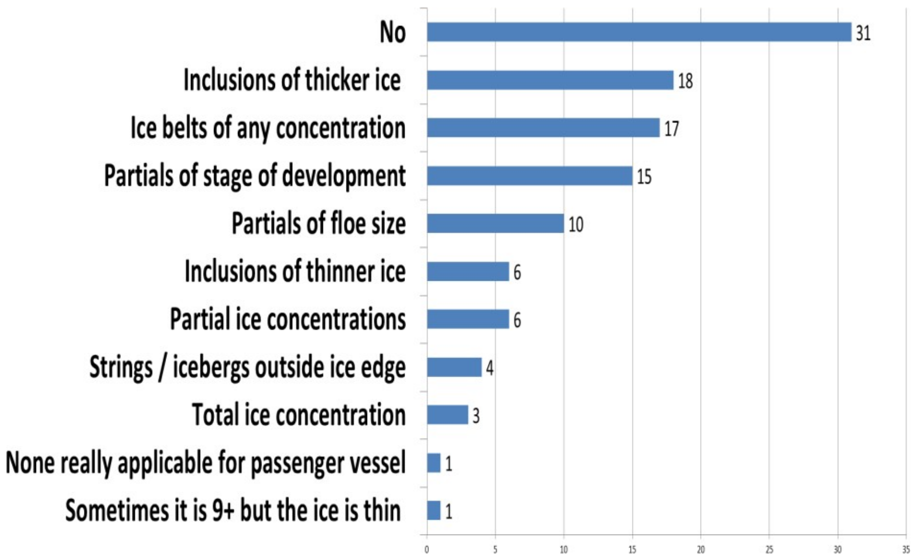
10. What is the acceptable minimum size of any ice (iceberg, ridge, floe, lead…) you need information about?



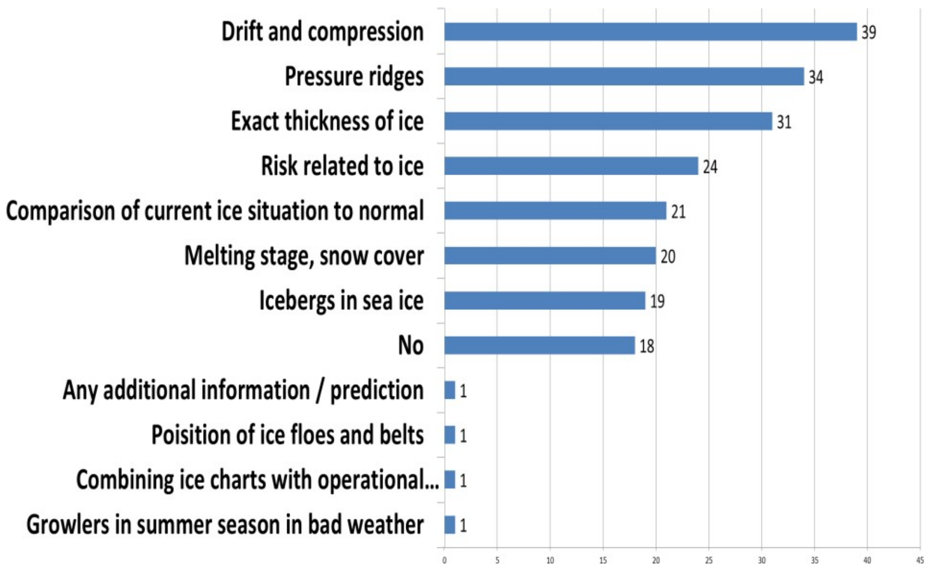
11. What is the optimal minimum size of any ice (iceberg, ridge, floe, lead…) you need information about?

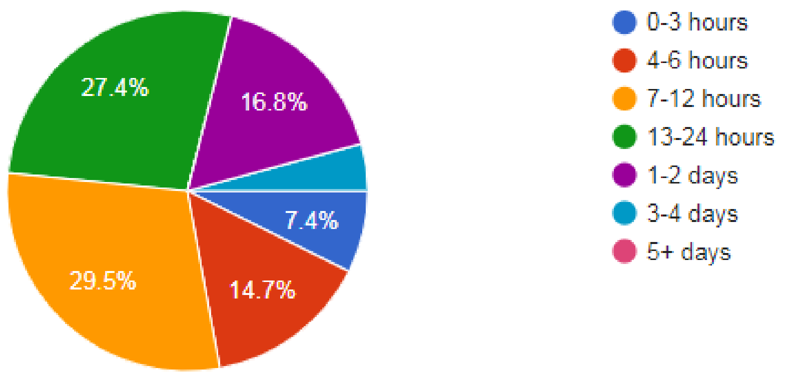
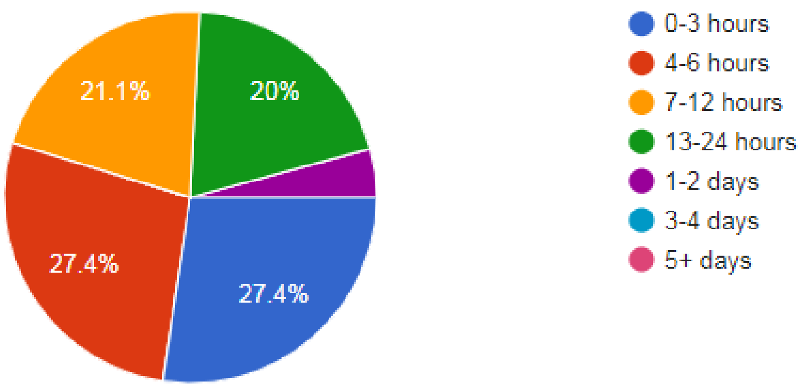
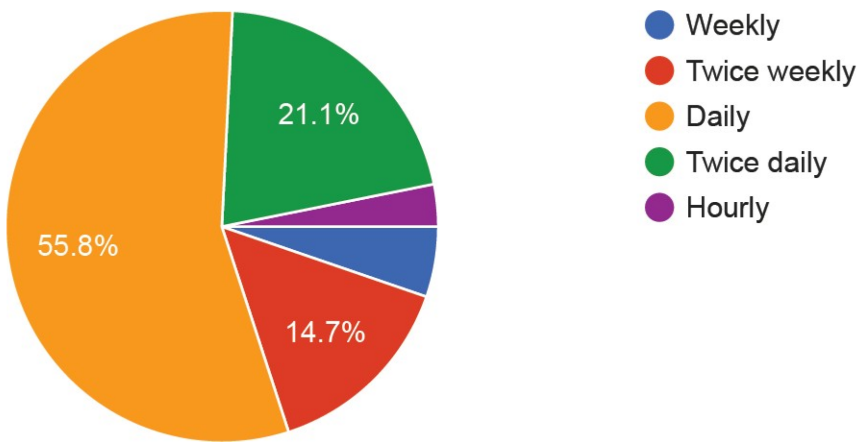


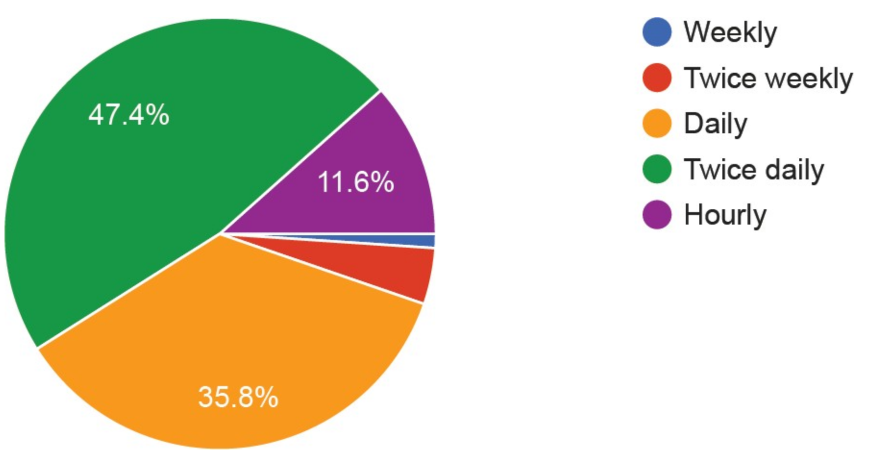
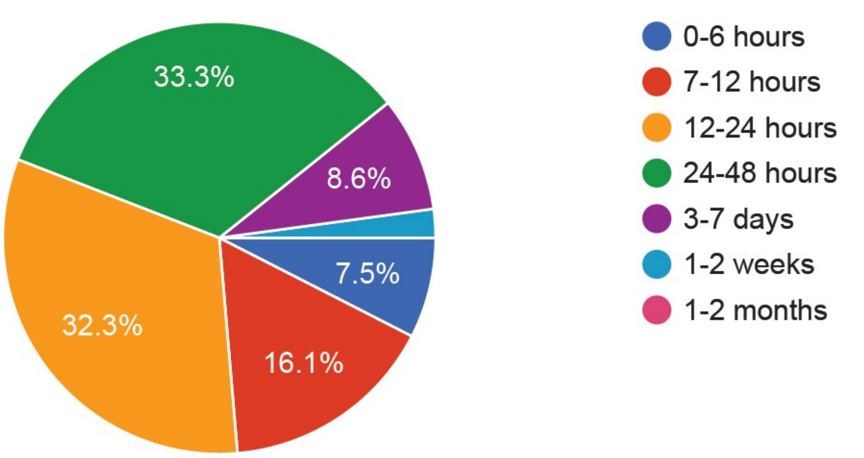
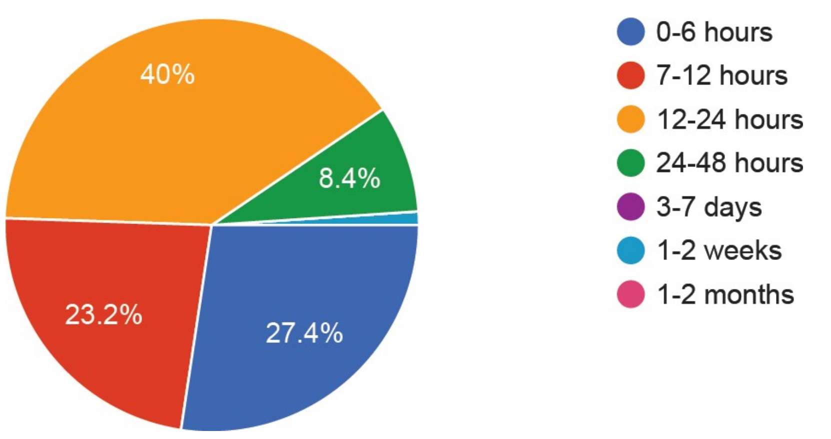
12. Are there any ice parameters currently on regional ice charts that you don't need? (select all that apply)



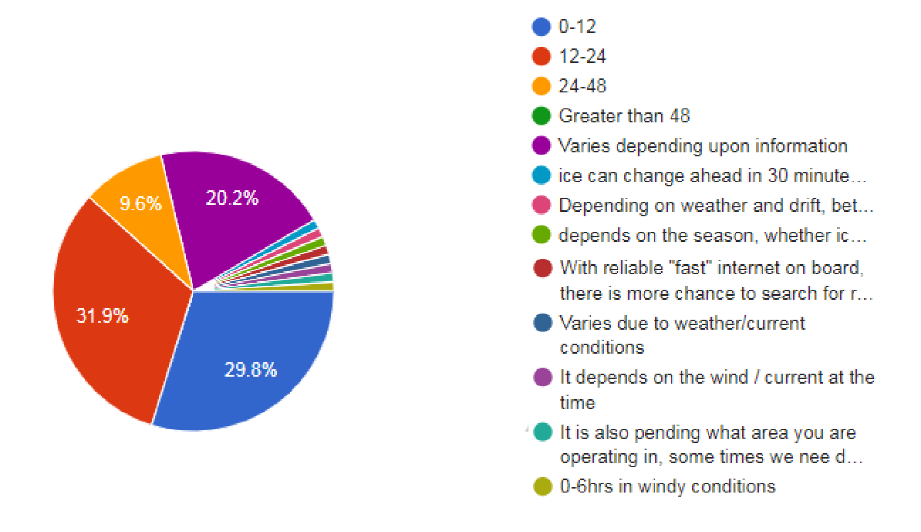
13. Are there ice parameters you are missing in ice products? (select all that apply)



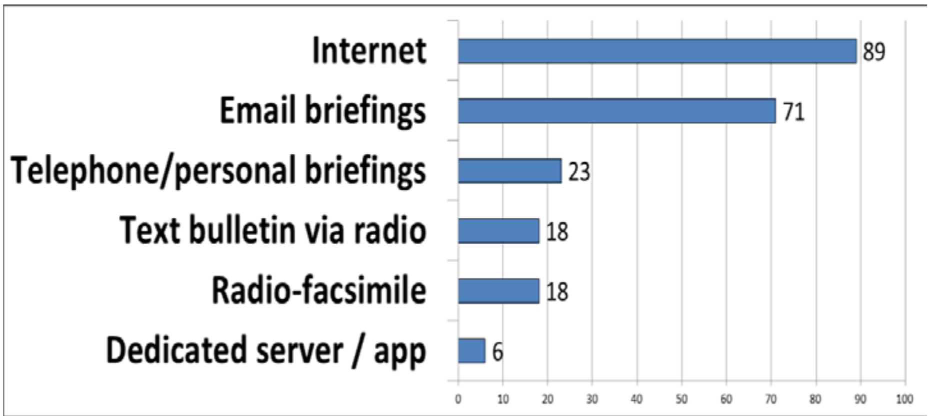
14. What is the acceptable level of ice product timeliness?	
15. What is the optimal level of ice product timeliness?	
16. What is the acceptable ice information update frequency for your needs?	

17. What is the optimal ice information update frequency for your needs?	
18. Which ice forecasting time scale is most critical for you on open seas?	
19. Which ice forecasting time scale most critical for you in ice, near ice, near shore?	

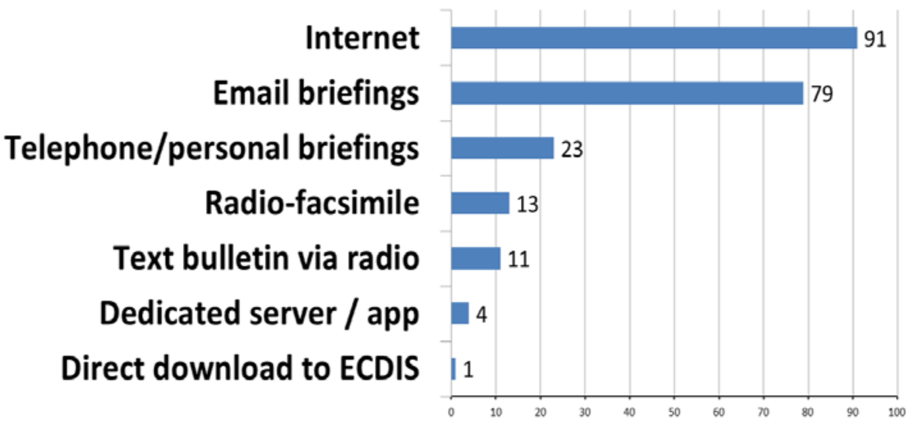
20. How long after the date/time of a product do you consider the information valid (in hours)?

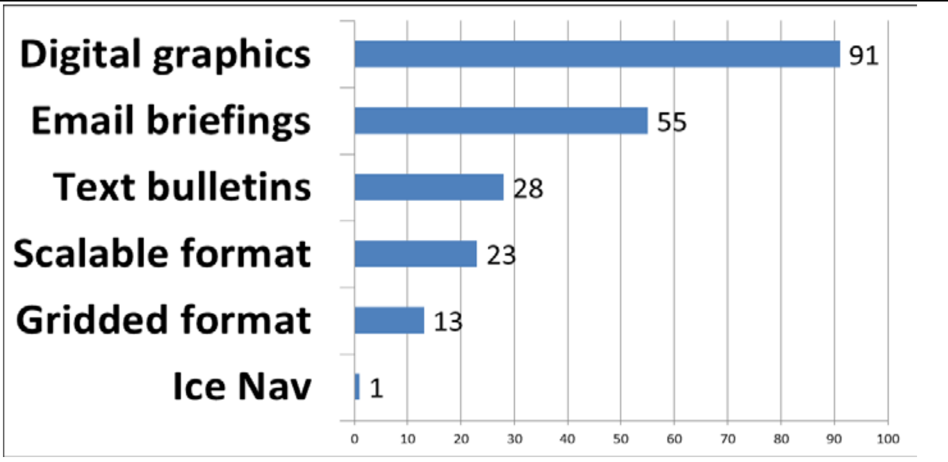
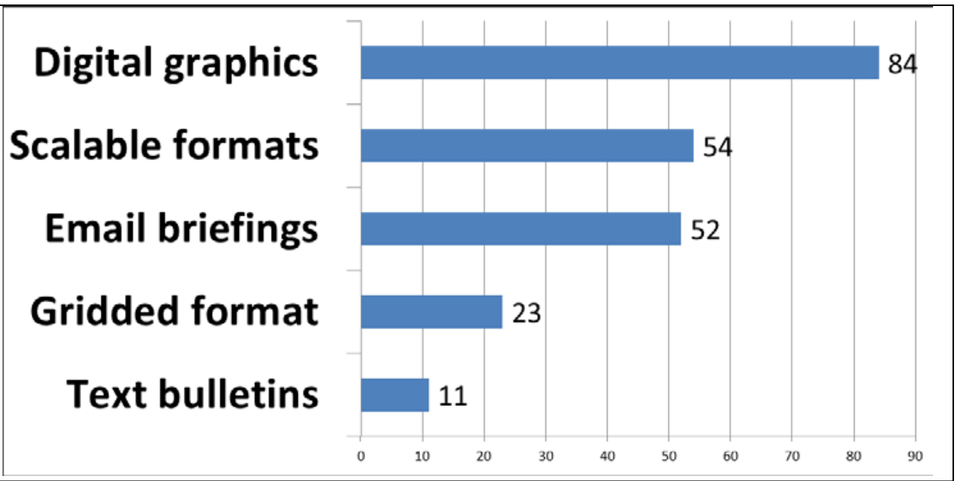
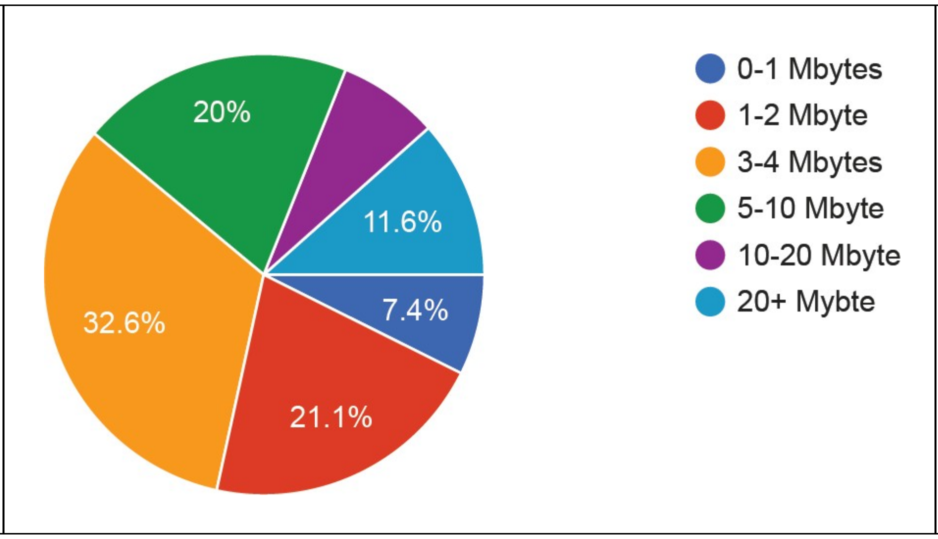


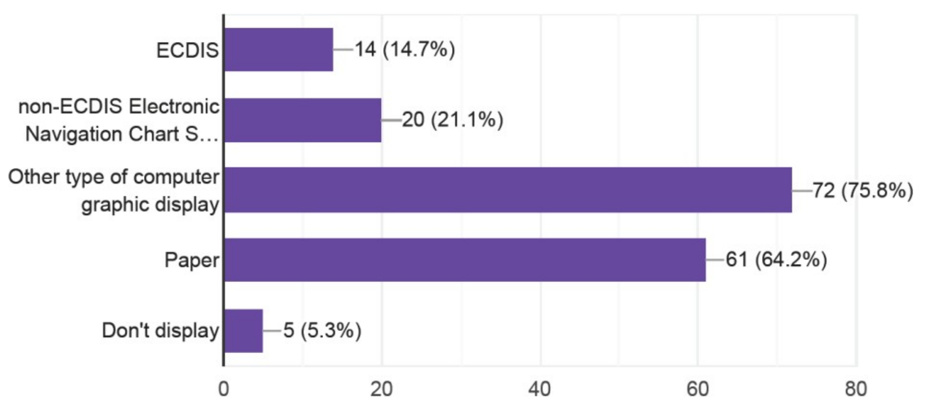
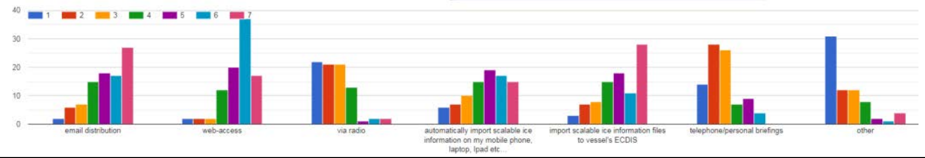
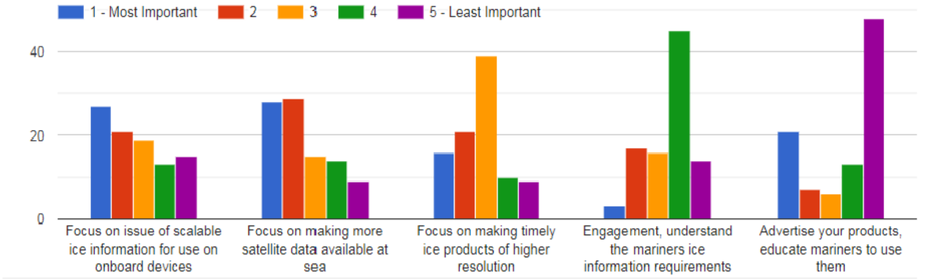
21. How do you receive ice information? (select all that apply)



22. How would you like to receive ice information in the future? (select all that apply)



23. Which ice information formats do you use/receive?	
24. Which ice information formats would you like to use in the future?	
25. What is the maximum file size you can receive?	

26. How do you display the ice information that you receive? (select all that apply)	
27. Please rank how you would like to access and use ice information in your daily life? (1.. least preferred, ..., 7 most preferred)	
28. Rank the actions below in order of criticality - what should the ice services focus on next? (1 - most important to 5 - least important)	

Appendix 6. Reports from INTAROS meeting participation

Table A6.1. Summary of stakeholder events during the first three years of the

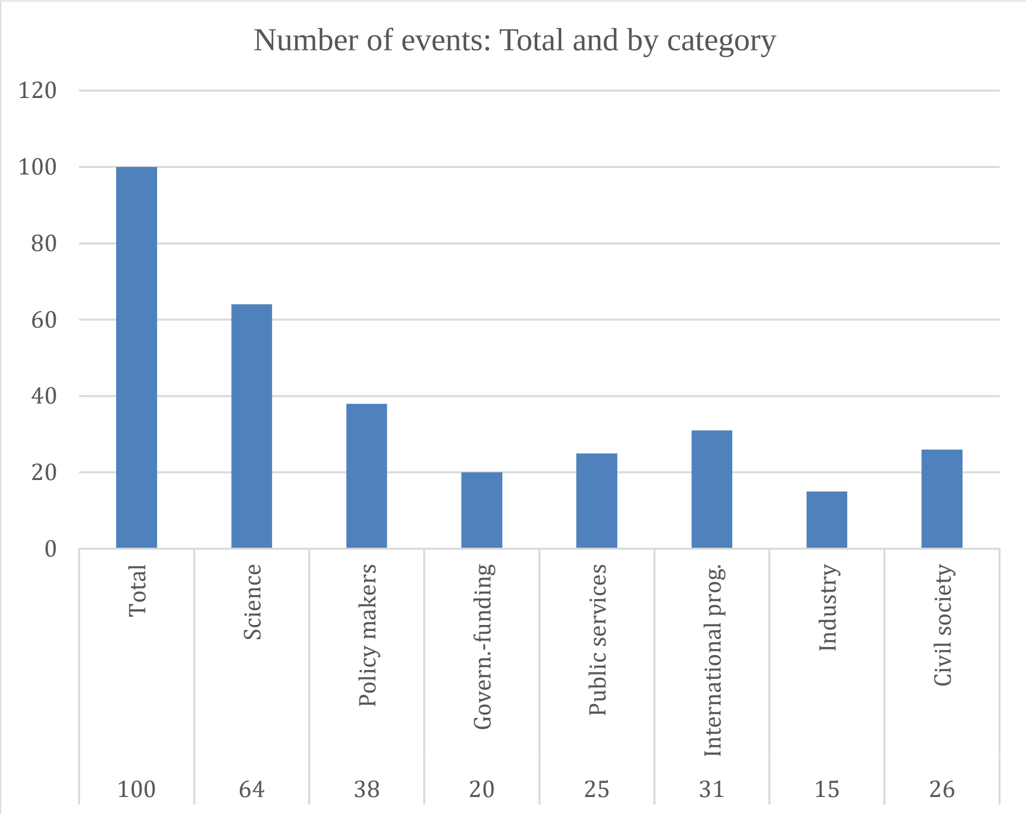


Table A6.1 List of individual events

Date	Event	Stakeholder group	INTAROS partners involved
2016			
05-09 Sept	YOPP planning meeting for Arctic observations at ECMWF, INTAROS presentation	ECMWF, Polar Prediction Progamme, YOPP community	S. Sandven, Y. Gao
05-07 Sept	ENVRI workshop on Arctic RI collaboration in Longyearbyen, INTAROS presentation	European research infrastructures for the Arctic	H. Sagen
07 Oct	Brokerage event at Arctic Circle, INTAROS presentation in session “operational Marine Services in the Arctic	Arctic Circle attendees: policy makers, civil society, industry, scientific community	S. Sandven
17 Oct	Visit to ONR in Washington, INTAROS presentation and planning of collaborative US project	Funding agency and research policy implementation (Transatlantic collaboration – Galway Declaration)	H. Sagen
17-18 Oct	Expert Forum on Implementation of the Year of Polar Prediction in Ottawa, organized by the MEOPAR programme	YOPP community in Canada	S. Sandven
8 Nov.	Presentation of INTAROS at Research Council of Norway	Funding agency, research policy	S. Sandven

8. Nov	Presentation of INTAROS at GEOCRI side-meeting at GEO Plenary in Sp. Petersburg	GEO community with interest in GEOCRI	L. H. Pettersson
8-9 Nov	Arctic Data Committee meeting at ESRIN	Arctic data community under SAON including ESA	T. Hamre
10-11 Nov	YOPP data meeting, Oslo	Norwegian Met Office and YOPP data community	T. Hamre
12 Nov	INTAROS presentation at COP22, Arctic Day event organized by Nordic Council of Ministers	COP 22 attendees at Arctic Day event,	H. Sagen
16-17 Nov	INTAROS presentation at ENVRI-Copernicus meeting in Prague	Representatives from ENVRI and Copernicus communities	H. Sagen
8 Dec	Community-Based Monitoring meeting in NUUK, organized by NORDECO I WP4	Government, civil society and science in Greenland	F. Danielsen
14 Dec	INTAROS Poster presentation at AGU, a dialogue with US Arctic research actors	Scientific community, Policy makers, funding agencies	H. Sagen, S. Sandven
2017			
20 Jan	INTAROS presented at EPOS-Norway Annual Workshop in Bergen: EPOS is the European Plate Observing system	Norwegian seismology community	K. Atakan, UiB
26 Jan	Presentation at Arctic Frontier by IOPAN	Scientific community, Civil society, Policy makers	A.B.-Møller
01 Feb	Presentation at National Biodiversity Symposium Denmark	Scientific community, Civil society, Policy makers	F. Danielsen
16 Feb	Presentation of INTAROS at Norwegian Environmental Agency	Governmental agency	S. Sandven, H. Sagen
01 March	PPP SG Meeting and join the YOPP Buoys and Floats Task Team, Maryland	YOPP community	A. B.-Möller
01-06 Mar	Visit to Chinese partners in INTAROS: PRIC, RADI, NMEFC) as well as Chinese Arctic and Antarctic Administration in Beijing	NMEFC provides forecasting for Chinese ships in the Arctic	S. Sandven, Y. Gao
29 Mar	INTAROS presented at Arctic meeting in Brussel - trilateral collaboration (US, EC and Canada), invited by EC	Funding agencies, programme managers, policy makers,	S. Sandven, H. Sagen, M. Sejr
4-7 April	Arctic Science Summit Week, Prague, INTAROS poster + presentation at SAON Board meeting	Scientific community, Industry, Civil society, Policy makers	S. Sandven, H. Sagen, T. Hamre, A. B. Møller
24-27 April	AMAP conference in Reston, Virginai, USA. INTAROS presentation	AMAP community members, policy makers	A. Ahlstrøm
05 May	INTAROS Stakeholder workshop	European agencies and RI's	Workshop report
09 May	OceanNoise 2017, Barcelona. Presentation of INTAROS	Underwater noise community: Scientists, Industry, Civil society, Policy makers	H. Sagen
11 – 12 May	Presentation of CBMs at Week of the Arctic, Fairbanks + open dialogue evening meeting Workshop report is available	Indigenous peoples organisations, scientists, policy makers, general public	F. Danielsen, Lisbeth Iversen, Hajo Eicken
31 My – 02 June	EuroGOOS General Assembly, Brussels	operational oceanography community in Europe	S. Sandven
11-16 June	POAC 2017 conference in Busan, Korea, INTAROS presentation	Scientists, Industry, Policy makers	S. Sandven
12 June	Presentation at Nordic Seismology Seminar, Helsinki	Seismology community members	P. Voss
13 June	Presentation at the 9th GRUAN Implementation and Coordination Meeting	Scientific community	R. Pirazzini

19-21 June	Presentation at 11th GEO European Projects Workshop, Helsinki	GEO community	S. Sandven
4 July	Presentation at 6th Euro-Argo Users Meeting,Paris	Euro-Argo community	H. Sagen
13 July	Presentation at "Enhancing Ocean Observations in the Atlantic from Antarctica to the Arctic", Lisbon	Scientific community, Civil society, Policy makers	N. Dwyer
31 July – 06 Aug	Interdisciplinary summer school on the Arctic and the Marginal Ice Zone, Svalbard,	Ca 30 PhD and postdocs working on various Arctic disciplines	S. Sandven
7-10 Aug	Exursion to Svalbard for junior highschool students from Bergen to learn about Arctic climate and the effects on local community in Longyearbyen	High school students	L. Iversen
24 Aug	A new window on Arctic greenhouse gases: Continuous observations from Ambarchik on the Arctic coast in North-East Siberia	Scientific community, Policy makers	M. Goeckede
30-31 Aug	Arctic Science Networking Workshop	Science community	S. Sandven
5 Sept	Presentation at GOOS Regional alliances	GOOS regional alliances	E. Buch
6-9 Sept	Presentation at Underwater Acoustic Conference, Skiatos.	Scientific and underwater acoustic community	H. Sagen
8 Sept	Presentation by EurOcean: Ocean Business Dialogues - Oceans Meeting, Lisbon,	Scientific community, Industry, Civil society, Policy makers, Media	N. Dwyer
14 Sept	Ocean acidification research at NIVA: observations, modeling, and experimentation.	Presentation at Norwegian Environment Agency, Oslo	K. Sørensen
16-18 Sept	Presentation at Arctic Data Committee annual meeting, Montreal	Scientific and Arctic Data community	T. Hamre
19-22 Sept	Presentation at PEEX Science Conference in Moscow	Scientific community	S. Sandven
25-29 Sept	Presentation at Copernicus Marine Week, Brussel	Copernicus marine community	S. Sandven
3-6 Oct	EuroGOOS conference, including emerging in situ biogeochemical observations using the FerryBox platform in Arctic waters	Marine research community	S. Sandven, ++
7 Oct.	Community-based monitoring in the Arctic, Prague, Talk at high-level forum for Russian indigenous peoples representatives	Civil society, indigenous people	F. Danielsen
13 Oct	Arctic Circle: "Scales across observations – connecting Arctic data, information and people" (S Sandven, GEOCRI session)	Arctic Circle community: Scientific community, Industry, Civil society, Policy makers, Media	S. Sandven
15 Oct	Arctic Circle: Monitoring Ocean, Ice and Land Chnages in the Warming Arctic - Polish Perspective	Arctic Circle community: Scientific community, Industry, Civil society, Policy makers, Media	A.B. Møller
17 Oct	8th FerryBox workshop, Oslo-Kiel	Science, industry	K. Sørensen
9 Nov	INTAROS side meeting at Svalbard Science conference in Oslo.	Norwegian research and operational agencies involved in Arctic observing	S. Sandven ++
13 Nov	Presentation at Worksop on subsea cables, Brest, France	Ocean science, underwater technology	H. Sagen

15 Nov	The Arctic Cluster/INTAROS presentation a side event at COP23 in Bonn with title "Polar insights for climate action	COP23 participants	S. Mernild, NERSC
17 Nov	Presentation at Polish Academy of Science in Warsaw on Arctic research and policy	Science, funding agencies, policy makers	S. Sandven, W. Walkowski
23 Nov	IMOBAR workshop, Brussels, input to policy document	EU event with Arctic projects	S. Sandven
28 Nov	Community-Based Monitoring in the Arctic, Public talk for EU	EU, Civil society, Policy makers	F. Danielsen
29-30 Nov	11th Arctic Shipping Summit in London, presentation of INTAROS	Arctic shipping community	S. Sandven
30 Nov	Participation in Arctic Future Symposium	Scientific community, policy makers	L. Iversen
11-15 Dec	Arctic Change conference, including INTAROS oranised workshop on CBM. Workshop report is available	Scientific community, policy makers	F. Danielsen, Lisbeth Iversen, Hajo Eicken
2018			
10 Jan	GLOBAL CRYOSPHERE WATCH STEERING GROUP (GSG) under WMO organised its Fifth Session at Norwegian Meteorological Institute. INTAROS presentation.	WMO / GCW community	Y. Gao, NERSC
22-25 Jan	Arctic Frontier, Tromsø, Poster presentation of INTAROS	Attended by science, industry, policy, indigenous people	S. Sandven, H. Sagen
23 Jan	The POGO-19 meeting in La Jolla, California, USA, with presentation of INTAROS by EuroGOOS	POGO members	G. Nowlan, EuroGOOS
8 March	European Ocean Observing System Forum in Brussel, participation in group work and discussions	Various stakeholders related to ocean observing systems	S. Sandven, H. Sagen
13 March	Meeting at Norwegian Environment Agency to present INTAROS	Norwegian Environment Agency (governmental agency)	S. Sandven, H. Sagen
19 March	INTAROS was presented at a side-meeting of the Arctic Council meeting in Levi, Finland. Topic of the meeting was EU's contribution to Arctic research and the preparations towards the Arctic Science Ministerial meeting.	Arctic policy makers from Finland, EU representatives incl. European External Action Service	Timo Vihma, FMI
11 April	Workshop in Tromsø on the interaction between research data and exploitation by various user groups, organised by the Norwegian infrastructure project NorDataNet (Norwegian Scientific Data Network) and INTAROS	Arctic data users: scientists, students and met-ocean services	S. Sandven, T. Hamre
23-25 May	EuroGOOS General Assembly, presentation of Arctic ROOS and INTAROS	EuroGOOS members, national operational ocean monitoring and forecasting institutions	S. Sandven
27-31 May	INTAROS-related presentations at Euronoise 2018, the 11th European Congress and Exposition on Noise Control Engineering in Crete. Acousticians and noise experts discussed recent research outcome and innovations in noise	Underwater acoustic industry, technology developers, and researchers	H. Sagen

	pollution, noise and vibration control, soundscape, and many related topics.		
24-26 June	Arctic Observing Summit, Davos, group work, presentations and discussions, prepare statement	Scientific community, Industry, Civil society, Policy makers, Media, General Public	S. Sandven, H. Sagen, M-N. Houssais, R. Pirazzini, F. Danielsen,++
25 June	European Maritime Day 2018, Burgas, Bulgaria, flyers distributed by Eurocean	Scientific community, Industry, Civil society, Policy makers, Media, Investors	N. Dwyer, Eurocean
4 July	CMEMS workshop in requirements for in situ data, presentation of INTAROS work on Arctic in situ data	People involved in Copernicus marine services	S. Sandven
30 August	Presentation of INTAROS at Danish Agency for Data Supply and Efficiency	Governmental Agency, Policy makers	O B Andersen
05 Sept	EARTHQUAKE MONITORING IN THE ARCTIC REGION - THE SEISMOLOGICAL COMPONENT OF INTAROS, presentation by UIB/GEUS at 36th General Assembly of the European Seismological Commission, Valetta, Malta	Scientific community, natural hazards	P. Voss
8 – 19 Oct	"Analysis of atmosphere-surface interactions and feedbacks" - intensive course for young scientists in Hyytiälä, Finland	Young scientists in atmospheric physics	R.Pirazzini
23-26 Oct	FAMOS School and workshop in Bergen, co-organised by NERSC/INTAROS (Forum for Arctic Modelling and Observational Synthesis)	Arctic scientists from Norway and USA	H. Sagen
24 Oct	The Arctic Observing Summit Executive Committee and the EU Joint Research Centre and SAON had organised a side meeting with the title "Towards a roadmap for coordinated Arctic Observing; approximately 80 people attended".	Participants in the Arctic Science Forum meeting (see below), Berlin 25 Oct	S. Sandven, F. Danielsen, ++
25 Oct	Arctic Science Forum meeting, with contribution from INTAROS	INTAROS provided input to Arctic observing systems towards the Arctic Science Ministerial meeting 26 Oct	≈ 20 scientists involved I INTAROS participated
28 Oct – 2 Nov	GEO week in Kyoto. Presentation of INTAROS poster	GEO community members	Hiroyuki Enomoto, NIPR
15 Nov	User meeting organized by the Norwegian Scientific Data Network (NorDataNet) and INTAROS: Title: "How can national and international research e-infrastructures support national geoscientific communities?".	Scientists and students working with geophysical data	S. Sandven, T. Hamre
21 Nov	EOOS conference organized by the EMODnet, European Marine Board and EuroGOOS Secretariats in close collaboration with wider stakeholder community and with financial support from the European Commission.	European organisations involved in ocean observing. Various stakeholders related to ocean observing systems	S. Sandven
02 -07 Dec	Research school on cross-disciplinary science in Longyearbyen	Ca. 30 young scientists	S. Sandven, H. Sagen, T. Hamre, +

6 Dec	Public lecture and workshop with local community members as part of the UAK research school in Longyearbyen. Workshop report is available	civil society, local community, policy makers	L. Iversen, S. Sandven
2019			
14-15 Jan	YOPP science conference, FMI, presentation of INTAROS	YOPP community	S. Sandven
23 Jan	ESOP-N annual meeting in Bergen. Seismological Monitoring in the Arctic through the INTAROS project	Scientific community in seismology	M. Sørensen
23 Jan	Arctic Frontier side event: Improved safety and environmentally sound operations in the Arctic Ocean	Science, operational services, Arctic Council EPPR, policy makers	S. Sandven, Ø Aarnes
7-8 March	Cruise expedition monitoring workshop, organized by INTAROS. Workshop report is available	AECO members, Longyearbyen community	L. Iversen, S. Sandven
2 April	ConocoPhillips April Seminar, presentation by G. Ottersen	Oil and gas industry, science, policy makers	G. Ottersen
25 April	ESOP-N workshop: Visualization and interpretation of natural hazards at Svalbard	Scientific community in seismology	M. Sørensen
29-30 April	Workshop on Arctic Ocean Observing Platforms and Technologies, organized by INTAROS	Science, technology developers, industry	H. Sagen, S. Sandven, T. Hamre, ++
13 May	Nordic Ocean and Climate workshop - IPCC's Special Report on the Ocean and Cryosphere in a Changing Climate	Science community, policy makers	G. Ottersen
10-11 May	Arctic Circle China Forum breakout session: ARCTIC SEA ICE CHANGES, organized by NERSC and PRIC	Science, policy makers	S. Sandven, S. Mernild, Y. Gao
15 May	Living Planet Symposium - Agora Session, "EC and ESA collaboration Polar Science Challenges and future activities". Presentation of INTAROS	ESA and EU policy makers	P. Goncalves
16-17 May	European Maritime Days, INTAROS presented at Eurocean booth	Policy makers,	R. Higgins
25-26 June	Arctic dialogue meeting and seminars were organised by the Research Council of Norway. INTAROS presentation	Policy makers, EU and NFR	S. Sandven
2-4 Sept	Arctic and Northern Ocean Forum, presentation of INTAROS	IEEE Oceanic Engineering Society.	Bin Cheng
8-13 Sept	Research School: Observing and modellng the Arctic Environment, NIERSC, St. Petersburg	Ca 30 Phd students	L. H. Pettersson, S. Sandven
16-22 Sept	OceanObs19, presentations of INTAROS in side meetings and community papers	Scientists, Policy makers	H. Sagen, A. B. Møller
4 Oct	Workshop on Arctic data at EEA in Copenhagen	EEA, Copernicus Marine services	A. Morvik, E. Buch
22-24 Oct	Course on CBM and collaborative management in Nuuk	Local policy makers, local communities	F. Danielsen
4 Nov	Side meeting on the Svalbard Social Science Initiative, SSSI, organised by INTAROS	Social Science community, Local community,	L. Iversen

5-6 Nov	Svalbard Science Conference: presentation of INTAROS work in Svalbard	Arctic science community, policy akers	S. Sandven

-- END OF REPORT --

INTAROS

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