ACCESS
Arctic Climate Change
Economy and Society


**Project no. 265863**

# ACCESS

## Arctic Climate Change, Economy and Society

Instrument: Collaborative Project
Thematic Priority: Ocean.2010-1 "Quantification of climate change impacts on economic sectors in the Arctic"

# D2.14 – Assessment of current monitoring and forecasting requirements from users and international providers of services

Due date of deliverable: **28/02/2012**

Actual submission date: 27/02/2012

Used Person/months: **2**

Start date of project: **March 1st, 2011** Duration: **48 months**

Organisation name of lead contractor for this deliverable: Met.no

| **Project co-funded by the European Commission within the Seventh Framework Programme (2007-2013)** | | |
|---|---|---|
| **Dissemination Level** | | |
| **PU** | Public | |
| **PP** | Restricted to other programme participants (including the Commission Services) | |
| **RE** | Restricted to a group specified by the consortium (including the Commission Services) | |
| **CO** | Confidential, only for members of the consortium (including the Commission Services) | X |

# Contents

# 1. Introduction

The current sea ice information requirements of a wide range of different user types relevant to the ACCESS project were assessed. A questionnaire was developed and sent out throughout 2011, and an analysis of the responses received is presented in this report.

The questionnaire was developed in association with the following projects and organisations:

## *1.1. SIDARUS*

Sea Ice Downstream Services for Arctic and Antarctic Users and Stakeholders (SIDARUS) (http://www.nersc.no/project/sidarus) is an European Commission (EC) EC Framework 7 Space (FP7-SPACE) project that is developing and implementing new sea ice information products for climate research, marine safety, and environmental monitoring to extend on those currently provided by GMES (Global Monitoring for Environment and Security) projects such as MyOcean (http://www.myocean.eu/).

## *1.2. ICEMAR*

ICEMAR (http://www.icemar.eu/) was chosen to develop a pilot ice service in response to the call for tender from the EC for GMES Pilot Services in the Atmosphere and the Maritime Areas. The overall objective is to establish a pilot downstream GMES sea ice information service to improve access to existing and new ice information products with the aim of aiding ships navigating near or within ice-infested waters in the European Arctic (primarily the Greenland and Barents Seas) and the Baltic Sea.

## *1.3. WMO EC-PORS*

The World Meteorological Organization (WMO) Executive Council Panel of Experts on Polar Observations, Research and Services (EC-PORS) (http://www.wmo.int/pages/prog/www/polar/index_en.html) was set up to promote and coordinate relevant programmes that are carried out in the Antarctic and Arctic regions by nations and by groups of nations. It interfaces with all WMO programmes, including the World Weather Watch (WWW), and other related programmes throughout the world, meeting global needs and requirements for meteorological observations, research and services in the polar regions.

The involvement of these projects and organisations enabled a set of questions to be put to the survey participants that covered a broader range of topics than those within WP2 and ACCESS alone. Sea ice information provision was covered, from the assessment of the types of product through to how to deliver that information to users who may be in remote places with limited communications bandwidth. In addition it was possible to ask for the users experience regarding the use of meteorological and oceanographic information.

A copy of the questionnaire is provided in Appendix A.

## 2. User Sectors

A number of sea ice information users were polled. Due to the involvement of the other projects, SIDARUS, ICEMAR, and EC-PORS, the questionnaire was used by a number of personnel at Met.no to sent to their user contacts and it was not possible to maintain tracking of exactly who had received it, or to remind users to complete it. It is estimated that the questionnaire was sent out to almost double the number of organisations that eventually responded. The range of sea ice information users polled covered all the known users and contacts of the Norwegian Ice Service. As the Ice Service information is publicly available without subscription, it was only possible to send the questionnaire to those users who have been in contact and whose contact details are known. Of the 24 that responded, there were 21 different organisations represented, covering a range of different user types.

The user organisations that responded were categorised, by their primary interest, into the different user sectors. The main users sectors were those involved in; shipping (ACCESS WP2) with 10, research with 7, and oil/gas (ACCESS WP4) with 4 respondents respectively. Air logistics, fishing (ACCESS WP3), and tourism sectors were under-represented with just one respondent in each of these categories. Figure 2-1 shows this breakdown graphically, and the list of users is provided in Table 2-1. The level of response from each sector reflects the contact the Ice Service has with its users. Sectors that are under-represented, such as the fishing, air logistics, and tourism, are known to use the ice charts but tend to be smaller scale operations where they utilise publicly available data and do not necessarily have the time or resources to interact with the provider.

Most (8 out of 21) of the organisations that responded were Norwegian (38.1%), with 2 each (9.52%) from Belgium, Canada, and Denmark. Australia, Finland, France, Netherlands, Russia, Sweden, and the United Kingdom each had 1 respondent (4.76%).

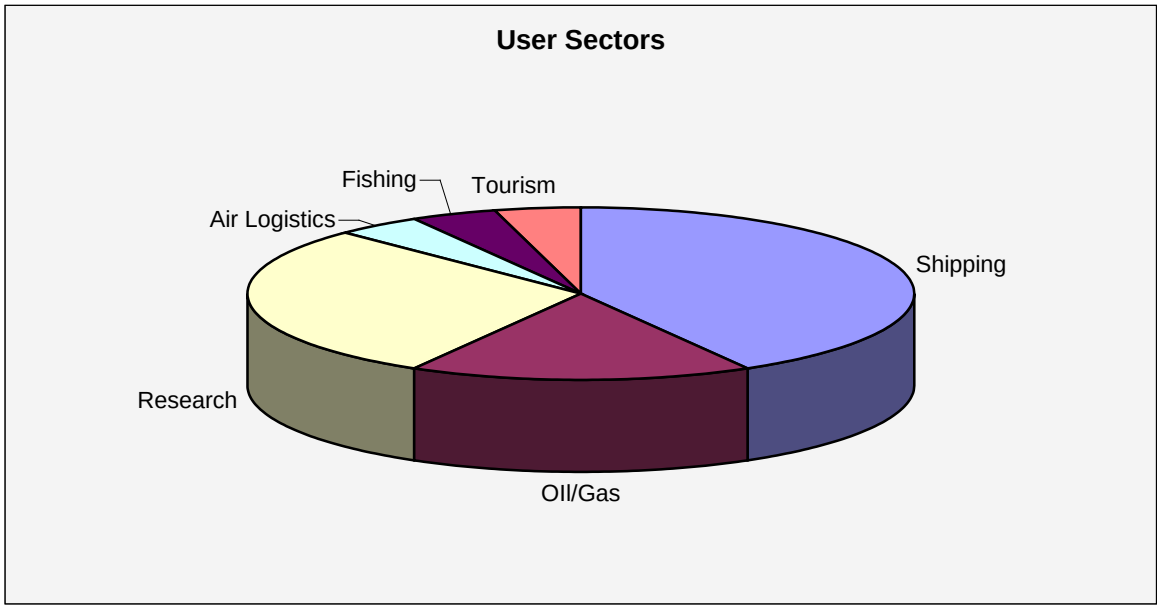


**Figure 2-1: Pie chart showing user sectors.**

## Use of sea ice information

The questionnaire respondents were asked about how they used sea ice information. This can be categorised under 5 levels:

- *Tactical use*
  Information and forecasts valid for any time from now up to 2 weeks, typically used for navigation.
- *Operational planning*
  Forecasts longer than 2 weeks, so normally 30-day up to seasonal to interannual. This type of information is generally used for route planning.
- *Strategic planning*
  Forecasts from years to decades in advance, used for development of new logistics and investment.
- *Historical information*
  For data retrieval or temporal integration.
- *Information integrated with existing user data*

Of these categories, the one on strategic planning is the most relevant to ACCESS. From the 24 responses, just over a third (9 users from 9 different organisations or 37.5%) said that they used strategic information. The types of user were fairly evenly split, with 3 users from oil/gas, 3 from research (climate modelling), 2 from shipping, and finally 1 from tourism. Discounting tourism, for which there was only 1 respondent, oil/gas were the user sector (with 75%) that made the most use of strategic planning for their activities.

This question was followed by one asking "W*hat areas of sea ice information provision are you interested in?*", with 3 options reflecting the projects interested in the results from the questionnaire:

- New types of sea ice information products from satellite and models
- Electronic delivery of sea ice information such as Electronic Navigation Charts (ENCs)
- Information on long-term changes to sea ice (effect of climate change) for strategic planning

These questions pertain to SIDARUS, ICEMAR, and ACCESS respectively, and the results are shown in Figure 3-1.

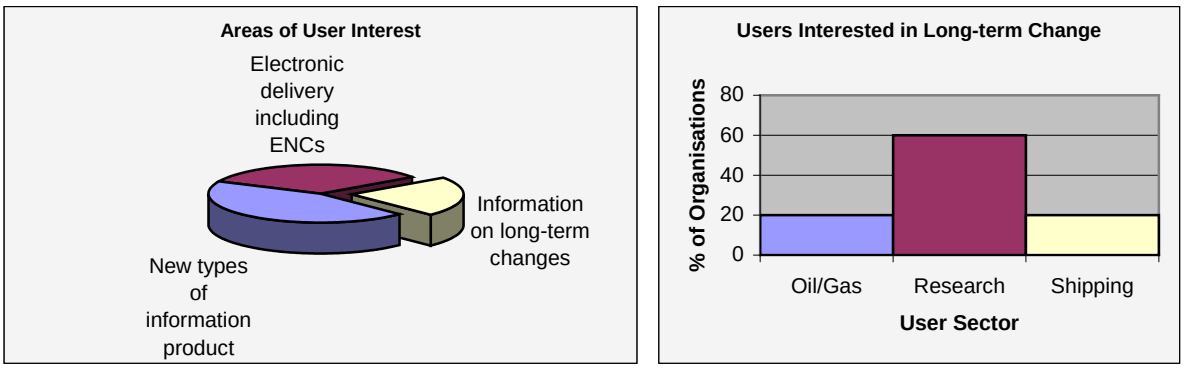


**Figure 3-1: Pie chart showing the split between the different areas of user interest, and then split within the information on long-term changes (ACCESS) sector.**

Some organisations were interested in more than one of these options, and 1 did not answer this question. All (20) were interested in new types of sea ice information product (SIDARUS), 15 (75%) were interested in electronic delivery of information (ICEMAR), and 10 (50%) were interested in long-term changes to sea ice (ACCESS).

Of the 10 organisations that were interested in long-term changes, 6 of these were from the research community (climate change modelling or studying ecology), with 2 each from the shipping and oil/gas user sectors.

# 3. Geographical Areas

Maps showing the geographical areas and sea routes of interest to the users in the Arctic and Antarctic are shown in Figure 4-1.

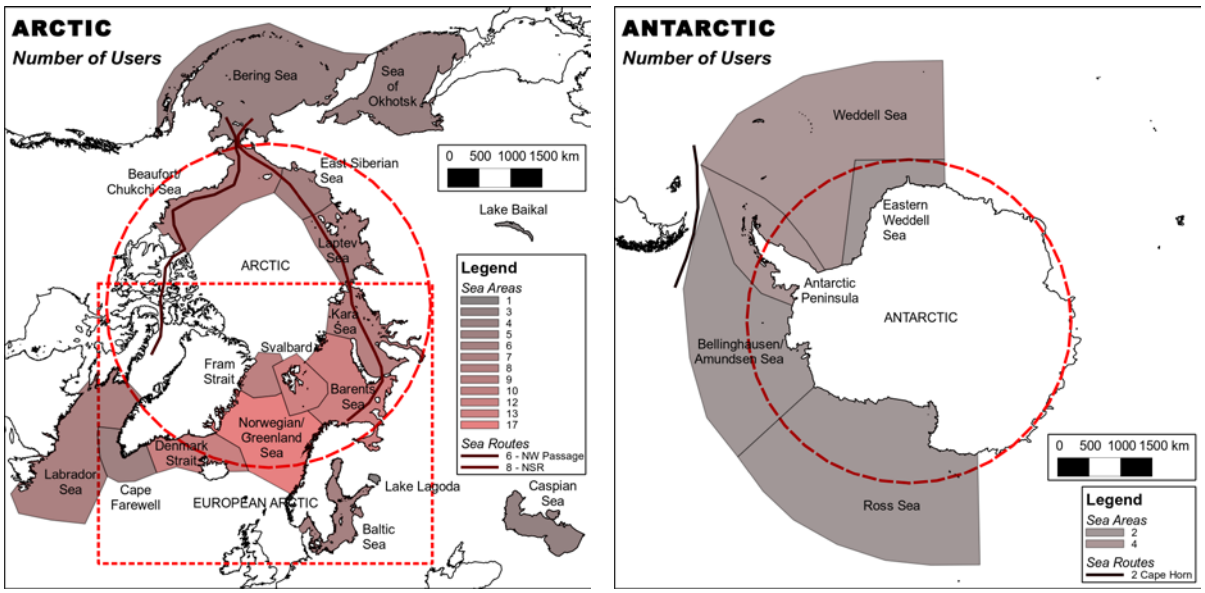


**Figure 4-1: Map showing geographical areas of sea ice information provision and numbers of interested users.**

All 21 organisations except the Australian Antarctic Division had an interest in the Arctic, and of those only 1 (University of Alberta, Canada) did not use European Arctic information. The main area of interest was the Greenland/Norwegian Sea (17 or 80.95%), with the neighbouring areas of the Barents Sea and Svalbard being joint second with 13 (61.9%), closely followed by the Denmark Strait (12 or 57.14%). Table 4-1 shows the breakdown between the different user sectors.

| *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 4-1: User sector breakdown for different Arctic sea areas.**

10 organisations were also interested in information from Arctic (and northern hemisphere) areas outside of the general European Arctic area. These results are shown in Table 4-2.

| *Geographical Area* | *Oil/Gas* | *Research* | *Shipping* | *Other* | *Total* |
|---|---|---|---|---|---|
| Caspian Sea | 2 | 1 | | | 3 |
| Sea of Okhotsk | 2 | 2 | | | 4 |
| Labrador Sea | 3 | 1 | 2 | 1 | 7 |
| Beaufort/Chukchi Sea | 3 | 3 | 2 | | 8 |
| Bering Sea | 1 | 2 | 1 | | 4 |
| Lake Ladoga | | 1 | | | 1 |
| Lake Baikal | | 1 | | | 1 |

**Table 4-2: User organisation interest in other northern hemisphere locations.**

For ACCESS WP2, 13 (61.9%) 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 4-3 summarised the shipping routes of interest, and this is also shown in Figure 4-2.

| *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 4-3: Shipping routes.**

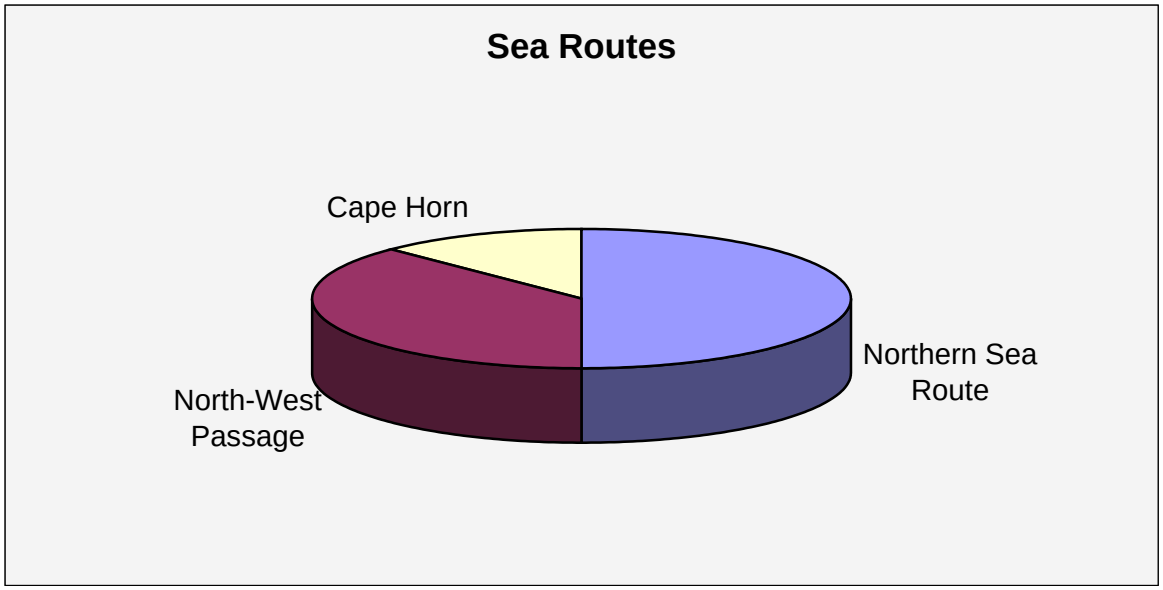


**Figure 4-2: Pie chart showing interest in different shipping routes.**

There was less interest in Antarctic areas amongst this set of users. Main areas of interest were the Weddell Sea and Antarctic Peninsula, with 4 (19.05%) users for each. The breakdown of user interest is shown in Table 4-4.

| *Geographical Area* | *Oil/Gas* | *Research* | *Shipping* | *Other* | *Total* |
|---|---|---|---|---|---|
| Weddell Sea | 0 | 2 | 1 | 1 | 4 |
| Ross Sea | 0 | 2 | 0 | 0 | 2 |
| Bellinghausen/ Amundsen Sea | 0 | 2 | 0 | 0 | 2 |
| Antarctic Peninsula | 0 | 2 | 1 | 1 | 4 |
| Eastern Weddell Sea | 0 | 2 | 0 | 0 | 2 |

**Table 4-4: Antarctic areas.**

# 4. 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.

## *4.1. 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 Table 5-1.

| | *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 |

**Table 5-1: Ice concentration requirements.**

## *4.2. 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. 16 (76.19%) of users wanted an ice edge product. Table 5-2 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 5-2: Ice edge requirements.**

## *4.3. 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 (Table 5-3).

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

**Table 5-3: Sea ice type (stage of development) requirements.**

## 4.4. 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 (Table 5-4).

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

**Table 5-4: Ice drift product requirements.**

## 4.5. 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, see Table 5-5. 12 (57.14%) of users wanted information on leads/polynyas, and 10 (47.62%) each for ridging and floe size.

| | *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 |

**Table 5-5: Ice deformation information requirements.**

## 4.6. 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 (Table 5-6).

| | *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 5-6: Sea ice thickness requirements.**

## 4.7. 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 respectively (Table 5-7).

| | *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 5-7: Iceberg information requirements.**

## 4.8. 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%) (Table 5-8).

| | *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 5-8: Other parameters.**

## 4.9. 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 (Table 5-9) 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 5-9: Summary of sea ice parameters.**

# 5. 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.

## *5.1. 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 (Table 6-1 and Figure 6-1).

| | *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 6-1: Meteorological parameters.**

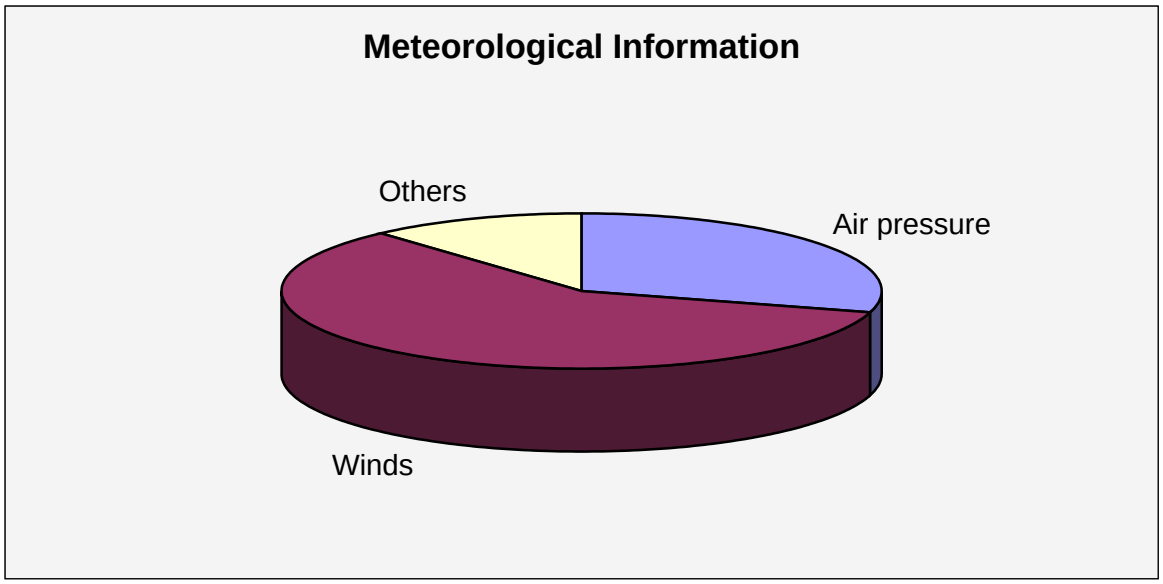


**Figure 6-1: Pie chart showing interest in different meteorological parameters.**

## *5.2. 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 (Table 6-2 and Figure 6-2).

| | *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 6-2: Oceanographic parameters.**

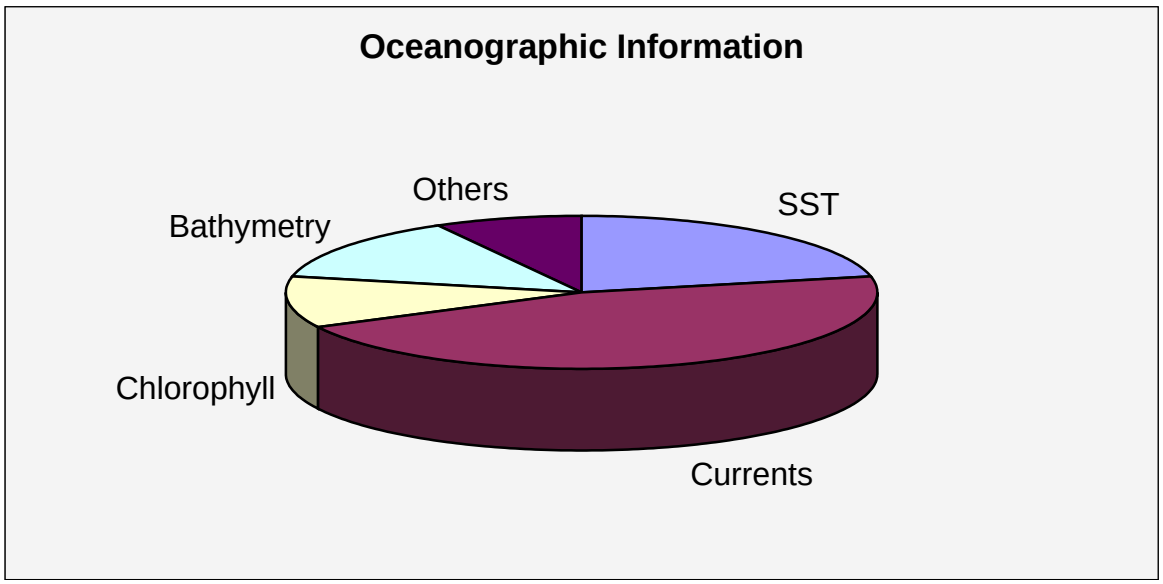


**Figure 6-2: Pie chart showing user interest in oceanographic parameters.**

# 6. Update Frequency and Level of Detail (Spatial Resolution)

The respondents were asked how often they required ice information to be updated. Table 15 summarised the responses between user sectors. "*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 (Table 7-1 and Figure 7-1).

| | *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 |

**Table 7-1: Update frequency.**

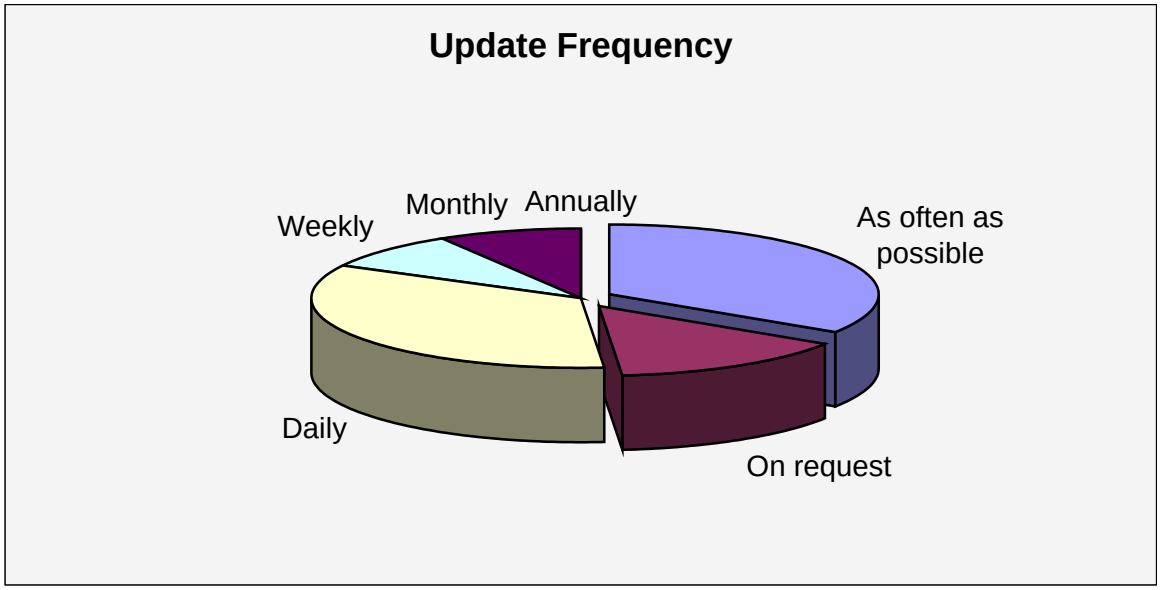


**Figure 7-1: Pie chart showing needs for update frequency.**

The participants were asked about the level of detail required in ice information products. The general answer was "*as much detail as possible*". The results are summarised in Table 7-2 and shown in Figure 7-2.

| | *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 7-2: Spatial Resolution.**

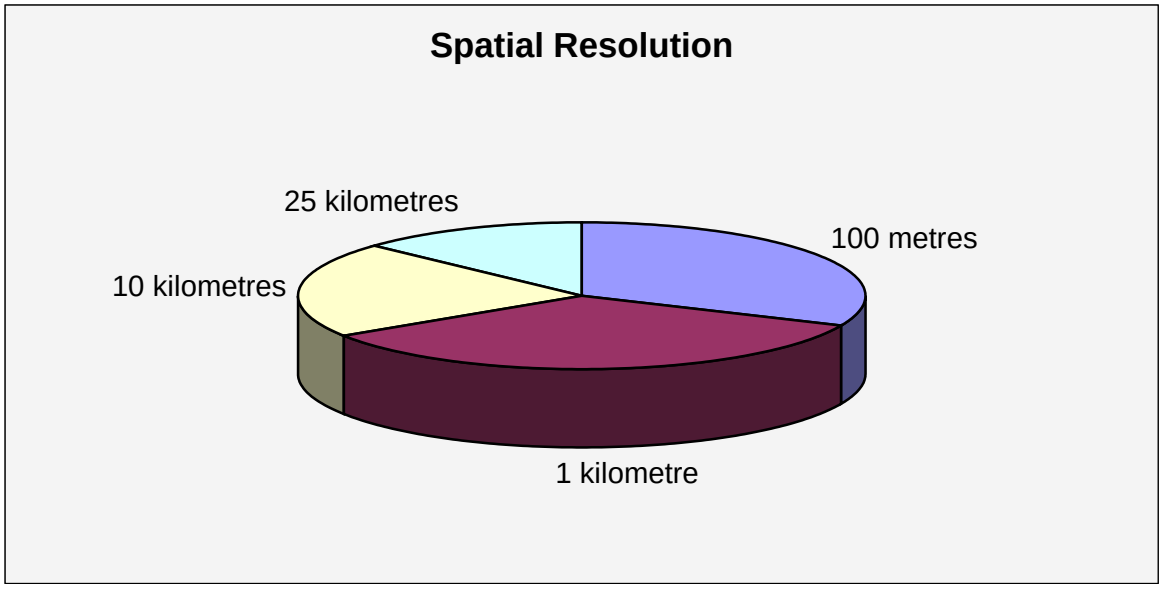


**Figure 7-2: Pie chart showing spatial resolution.**

# 7. 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 (Table 8-1). 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 8-1: Tactical and operational forecasts.**

Table 8-2 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 8-2: Strategic forecasts.**

# 8. Conclusions

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 symbologies, 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. The follow-up questionnaire should aim to include the results of long-term forecasting done under WP1 with examples of scenarios of how future changes might affect user sector operations, so that the questions ask better reflect the user assessment of how changes will affect them.

# 9. Appendix A – Questionnaire

QUESTIONNAIRE

Your Name: _____
Name of organisation: _____
E-mail: _____
Telephone: _____

## Part I – Sea ice information

**What area is your organisation involved in?**

| | | | |
|---|---|---|---|
| ☐ Fisheries | ☐ Oil/Gas | ☐ Research | ☐ Shipping |
| ☐ Air Logistics | ☐ Government inspection | ☐ Insurance | ☐ Ferries |
| ☐ Government environmental | ☐ Tourism/ Adventure | ☐ Other | ☐ Wildlife |

**How do you use sea ice information?**

| | | | | |
|---|---|---|---|---|
| ☐ Tactical use (hours up to 2 weeks), e.g. navigation | ☐ Operational planning (30-day, seasonal to interannual), e.g. route planning | ☐ Strategic planning (years, decades), e.g. development of new logistics and investment | ☐ Historical information, eg, for data retrieval or for temporal integration | ☐ Information integrated with existing user data |

**What areas of sea ice information provision are you interested in?**

☐ New types of sea information products from satellite and models

☐ Electronic delivery of sea ice information such as Electronic Navigation Charts (ENCs)

☐ Information on long-term changes to sea ice (effect of climate change) for strategic planning

**What geographical areas would you like to see covered?** (Please tick all that apply)

| Basic | Detailed | | |
|---|---|---|---|
| ☐ Arctic (north of 60°N) | ☐ European Arctic | ☐ Baltic Sea | ☐ Barents Sea |
| | ☐ Kara Sea | ☐ Greenland/Norwegian Sea | ☐ Fram Strait |
| | ☐ Svalbard | ☐ Denmark Strait | ☐ Cape Farewell |
| | ☐ Laptev Sea | ☐ East Siberian Sea | |
| ☐ Other Areas | ☐ Caspian Sea | ☐ Sea of Okhotsk | ☐ Labrador Sea/Baffin Bay |
| | ☐ Beaufort/Chukchi Seas | ☐ Bering Sea | ☐ Ladoga Lake |
| | ☐ Baïkal Lake | | |
| ☐ Antarctic (south of 50°S) | ☐ Weddell Sea | ☐ Ross Sea | ☐ Bellinghausen Sea |
| | ☐ Antarctic Peninsula | ☐ Eastern Weddell Sea | |
| ☐ Shipping Routes | ☐ Northern Sea Route | ☐ North West Passage | ☐ Cape Horn |
| Other areas not shown here: | | | |

**What types of sea ice information do you find most useful?** (Please tick all that apply)

| Basic | Detailed | | |
|---|---|---|---|
| ☐ Concentration | ☐ Percentage cover | ☐ Coverage in classes (e.g. Open Drift Ice (4/10-7/10th), Very Close Drift Ice (9/10-10/10th) | ☐ Ice or No Ice |
| ☐ Edge | ☐ Detailed ice edge line | ☐ Simplified ice edge line (e.g. 10-20 longitude/latitude coordinates) | |
| ☐ Type | ☐ WMO Ice Classes | ☐ Simplified (Open Water, First-Year, Multi-Year) | |
| ☐ Drift | ☐ Low resolution (10 km) | ☐ High resolution (1 km) | |
| ☐ Deformation | ☐ Ridging | ☐ Leads and Polynyas | ☐ Floe Size |
| ☐ Thickness | ☐ Actual values<br>☐ Mean Average Thickness | ☐ Thickness in classes (e.g. WMO Ice Classes)<br>☐ Modal Average Thickness | |
| ☐ Icebergs | ☐ Occurrence<br>☐ Shape (Normal/Tabular) | ☐ Size | ☐ Drift |
| ☐ Other Parameters | ☐ Snow Cover<br>☐ Water Cover on ice | ☐ Surface Temperature (Freezing/Melting) | |
| Other types of information not shown here: | | | |

**What types of environmental parameters do you find most useful?** (Please tick all that apply)

| Basic | Detailed | | |
|---|---|---|---|
| ☐ Meteocean information | ☐ Air Pressure | ☐ Wind | ☐ Others |
| ☐ Oceanographic information | ☐ SST | ☐ Current<br>☐Chlorophyll<br>☐Bathymetry | ☐ Others |
| Other types of information not shown here: | | | |

**How much detail in time, how often would you like to have information updated?** (Please tick all that apply)

☐ As often as possible ☐ Daily ☐ Monthly ☐ Annually ☐ On request for historical data

☐ Weekly

**How spatially detailed should this information be?**

☐ 100 metres ☐ 1 kilometre ☐ 10 kilometres ☐ 25 kilometres

**What time period of tactical and operational ice forecast (short-term) information is most useful?** (Please tick all that apply)

☐ Not applicable

☐ 2-3 days ☐ week ☐ month ☐ 3 months (seasonal)

☐ 1 year

**Do you have a requirement for long-term predictions, i.e. on the effect of climate change on sea ice?**

☐ Not applicable
☐ Years ☐ Decades

**What time period of historical information would be useful?**

☐ Not applicable ☐ 1 year ☐ More than 1 year ☐ Less than 1 year

**How would you like information delivered?** (Please tick all that apply)

☐ Download from web site ☐ E-mail ☐ Electronic Navigation Charts (ENCs) ☐ Navtex
☐ AIS ☐ Other, please specify

**Size of product information (I.e. dependent on your communication bandwidth, e.g. low for satellite)**

☐ Less than 256 characters ☐ E-mail text only < 10 Kb ☐ Iridium < 100 Kb ☐ E-mail with graphics < 1Mb
☐ Unlimited (Full Internet access)

**What electronic data formats do you prefer?**

| | | | |
|---|---|---|---|
| ☐ Images | ☐ JPEG/PNG/PDF | ☐ GeoTIFF | ☐ JPEG2000 (streaming) |
| | ☐ GeoPDF | ☐ NetCDF | ☐ Text (ASCII) |
| ☐ Vector | ☐ Shapefile | ☐ S-100 for ENCs | ☐ Text (ASCII) |

Other formats not shown here:

## Part II – Weather and oceanographic information

World Meteorological Organization
Working together in weather, climate and water

A Task Team under the WMO's Executive Council Panel of Experts on Polar Observations, Research and Services, Services is gathering input to assess user/customer needs and perspectives on weather, water, and climate products in the Polar Regions in consideration of a Global Integrated Polar Prediction System. Thank you for providing your valuable input.

**How do you use weather and Ocean information?**

Please grade the impact of weather information on your business (1=imperative for reducing the costs and risks, 2= has a reducing effect on costs and risks, 3= useful but difficult to quantify, 4=insignificant. Please tick one per line.)

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Tactical use (hours up to 2 weeks), e.g. navigation | ☐ | ☐ | ☐ | ☐ |
| Operational planning (30-day, seasonal to interannual), e.g. route planning | ☐ | ☐ | ☐ | ☐ |
| Strategic planning (years, decades), e.g. development of new logistics and investment | ☐ | ☐ | ☐ | ☐ |

Please grade the impact of ocean information (waves, currents, sea level, temperature etc) on your business (1=imperative for reducing the costs and risks, 2= has a reducing effect on costs and risks, 3= useful but difficult to quantify, 4=insignificant. Please tick one per line.)

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Tactical use (hours up to 2 weeks), e.g. navigation | ☐ | ☐ | ☐ | ☐ |
| Operational planning (30-day, seasonal to interannual), e.g. route planning | ☐ | ☐ | ☐ | ☐ |
| Strategic planning (years, decades), e.g. development of new logistics and investment | ☐ | ☐ | ☐ | ☐ |

**How do you currently receive weather and ocean information?**
[open question]

**What types of weather and ocean information do you find most useful**
[open question]

**How much detail in time, how often would you like to have weather information updated?**
(Please tick all that apply)
☐ As often as possible ☐ Daily ☐ Monthly ☐ Annually

**How much detail in time, how often would you like to have ocean information updated?**
(Please tick all that apply)
☐ As often as possible ☐ Daily ☐ Monthly ☐ Annually

**How spatially detailed should the weather information be?** (1=imperative for reducing the costs and risks, 2= has a reducing effect on costs and risks, 3=useful but difficult to quantify, 4=insignificant. Please tick one per line.)

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 100 m | ☐ | ☐ | ☐ | ☐ |
| 1 kilometre | ☐ | ☐ | ☐ | ☐ |
| 10 kilometres | ☐ | ☐ | ☐ | ☐ |
| 25 kilometres | ☐ | ☐ | ☐ | ☐ |

**How spatially detailed should the ocean information be?** (1=imperative for reducing the costs and risks, 2= has a reducing effect on costs and risks, 3=useful but difficult to quantify, 4=insignificant. Please tick one per line.)

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 100 m | ☐ | ☐ | ☐ | ☐ |
| 1 kilometre | ☐ | ☐ | ☐ | ☐ |
| 10 kilometres | ☐ | ☐ | ☐ | ☐ |
| 25 kilometres | ☐ | ☐ | ☐ | ☐ |

**What time period of tactical and operational weather forecast (short-term) information is most useful?** (Please tick all that apply)

☐ Not applicable

| | | | |
|---|---|---|---|
| ☐ 0-6 hours | ☐ 6-24 hours | ☐ 2-3 days | ☐ week |
| ☐ month | ☐ 3 months (seasonal) | ☐ 1 year | |

**What time period of tactical and operational oceanographic forecast (short-term) information is most useful?** (Please tick all that apply)

☐ Not applicable

| | | | |
|---|---|---|---|
| ☐ 0-6 hours | ☐ 6-24 hours | ☐ 2-3 days | ☐ week |
| ☐ month | ☐ 3 months (seasonal) | ☐ 1 year | |

**Medium-term forecasts often are associated with an estimate of the forecast uncertainty, or alternative development paths. Is the forecast uncertainty for your purpose** (Please tick all that apply)

| | | | |
|---|---|---|---|
| ☐ essential | ☐ useful | ☐ difficult to use | ☐ distractive |

**Further contact?**

☐ Would you like to receive example products from SIDARUS and provide feedback to the project?

☐ Would you like to be contacted by SIDARUS Project Team regarding becoming a member of the user group for SIDARUS and helping specify and review sea ice information product needs.

☐ May the WMO executive council panel for experts for polar services contact you for further information on your needs?

Other Comments?

**SIDARUS** contact for user interaction:

| | |
|---|---|
| Frode Dinessen (met.no) | Frode.dinessen@met.no |
| Aline Duplaa (CLS) | aduplaa@cls.fr |