ACCESS
Arctic Climate Change
Economy and Society

Project no. 265863

ACCESS Arctic Climate Change, Economy and Society

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D2.15 – Assessment of future monitoring and forecasting requirements based on scenarios supplied by WP1 and WP2

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PU	Public	X
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)	

1. Introduction

The previous survey for ACCESS project work package 2.14 from the original questionnaire titled "*D2.14 – Assessment of current monitoring and forecasting requirements from users and international providers of services," (*https://wiki.met.no/_media/access/deliverables/d2-14-met.no-websiteversion.pdf) concluded that users of sea ice charts require as much information on different parameters as possible with the best detail available, and that this be 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.

The first survey provided a good ratio between shipping, oil/gas, and research among the organisations that responded to the questionnaire, however, there was a strong bias towards Norwegian respondents that affected the questions asked about interest in geographical areas towards local sea regions. This document will plan to address a follow-up questionnaire to the same users when presented with predictions of climate change and will inquire how their needs will change based on this information. Under half of the responding organisations who filled out the previous survey 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. This follow-up questionnaire includes the results of long-term forecasting done under WP1 with CMIP5 models and 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.

Between the end of the previous survey and the development of this second survey there has been work done on the assimilation of high resolution data products derived from satellite sensors such as SAR and optical for forecast models. However, as of yet there is no available operational product that can be used as one of the follow-up requirements for this survey. Therefore, the following survey will provide necessary information to the users related to the outcomes from ACCESS *D1.51 – "Results of Arctic ocean-sea ice downscaling runs validated and documented,"* provided by the Alfred Wegner Institute (AWI) and *D2.42 - "Calculation of fuel consumption per mile for various ship types and ice conditions in past, present and in future,"* provided by Hamburgische Schiffbau-Versuchsanstalt (HSVA). This information will be compiled and for a final report for the ACCESS project after all the responses are received.

2. Background

To summarize, the previous survey polled sea ice information users in several different sectors which included industry, operations, research, air logistics, fishing, oil/gas, and tourism, and included known users and contacts of the Norwegian Ice Service. 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. Sectors that were 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.

This survey aims to make this new information available related to long-term forecasts and future strategic planning when navigating through Arctic waters as a follow-up from the previous survey, but also to engage previously under-represented sectors.

3. Relevant survey outcomes from ACCESS D2.14

This questionnaire will focus responses from the the Strategic Planning, Historical Information, and Information integrated with existing user data sections described in the previous survey in ACCESS D 2.14. Strategic planning was the most relevant to ACCESS per the previous survey; however, information on how we can improve the accessibility of historical information and existing data relevant for current users. Information from the previous outcomes will be included in this report prior to the survey.

3.1 Geographical Areas

Maps showing the geographical areas and sea routes of interest to the users in the Arctic are shown in Figure 3-1 (from ACCESS report D2.14).

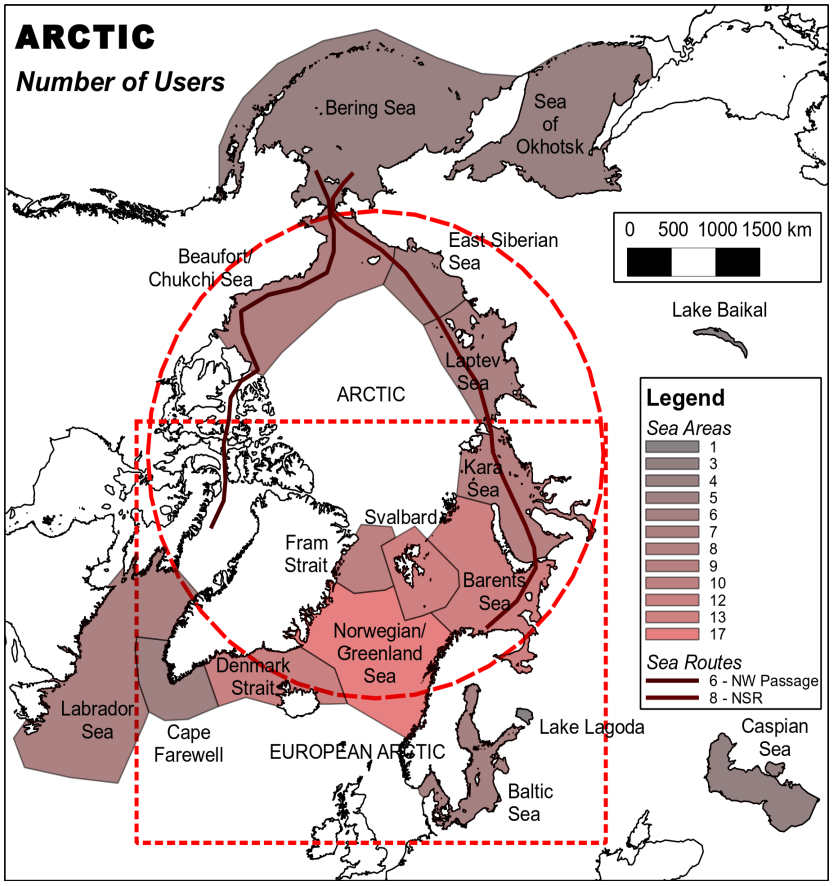

Figure- 3-1: Map showing geographical areas of sea ice information provision and numbers of interested users.

The previous survey showed that 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 3-1 shows the breakdown between the different user sectors.

Table 3-1: User sector breakdown for different Arctic sea areas.

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

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 3-2.

Table 3-2: User organisation interest in other northern hemisphere locations.

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

For ACCESS WP2, 13 (61.9%) respondents were interested in information covering shipping routes. Of these 8 (61.54%) were Northern Sea Route (NSR). 6 (46.15%) North-West Passage (NWP), and 4 (30.77%) both. In addition 2 (15.38%) were interested in ice information provision (icebergs) around Cape Horn. The shipping routes of interest were summarized, and this is also shown in Table 3-3 and Figure 3.2.

Table 3-3: Shipping routes.

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

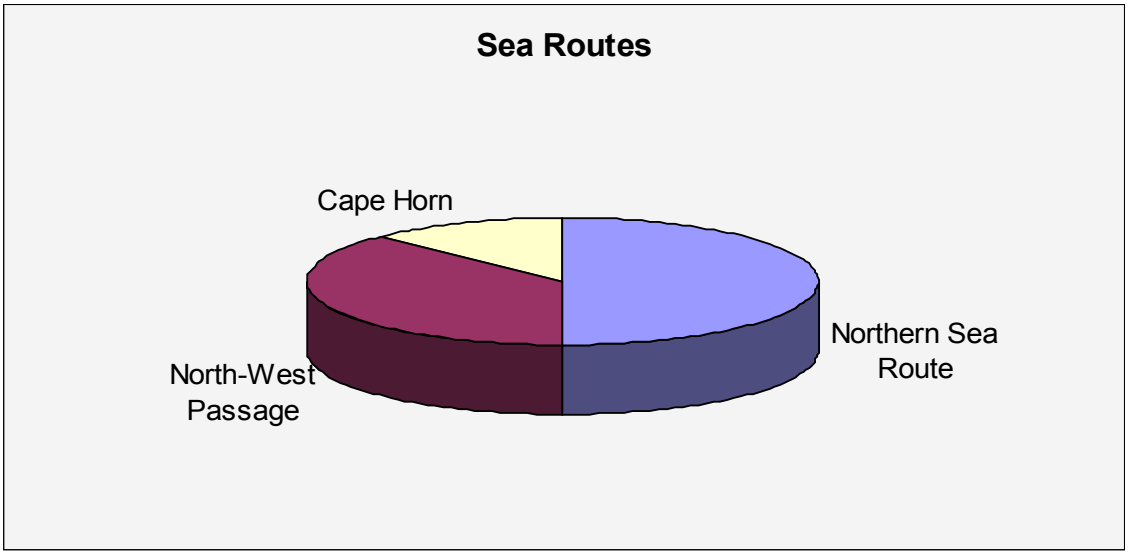

Figure 3.2. Pie chart showing interest in different shipping routes.

From the first part of the survey Strategic planning in the NWP and the NSR were considered to be the most important areas to users. The following will provide information from HSVA on the most efficient method of travel along the NSR based on future scenarios of sea ice conditions. We will then provide outcomes from the best CMIP5 climate models for sea ice concentrations along the NSR provided by AWI. We have no information at this time for the NWP due to the lack of available sea ice information, uncertainties, and the coarse nature of current climate models in that area.

4. Summary of Cost Effective Methods of Travel along the Northern Sea Route

As described in the ACCESS report: ***D2.42 - Calculation of fuel consumption per mile for various ship types and ice conditions in past, present and in future*** *(https://wiki.met.no/_media/access/deliverables/d2_42-hsva_report_ce_cs_nr_rev02_submitted.pdf)* HSVA developed the ETA (Estimated Time of Arrival) project ARCDEV in 1998 and is based on semi empirical - analytical formulations for predicting ship resistance in different ice covered environments. They used data from the specific propulsion arrangement of different vessel types and calculated the required power to obtain the maximum attainable speed based on several different levels of resistance, speed, and water effects. Four different routes along the NSR were used which were defined based on current knowledge of shipping routes and according to the required spatial resolution with regard to variations in environmental conditions (Figure 4-1 through 4-4). The longest distance begins with Route 1 and ends at the shortest distance with Route 4.

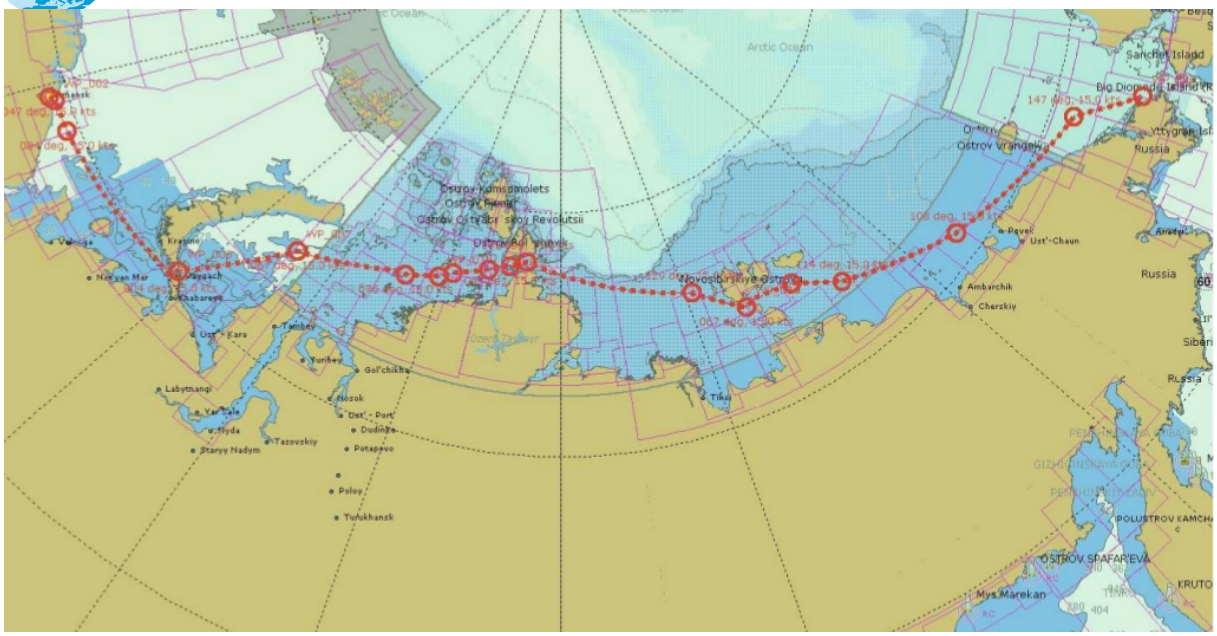

Figure 4-1. HSVA Route 1 along Northern Sea Route, south of Novaya Zemlya and south of Novo Siberian Islands *(Nils Reimer, HSVA)*

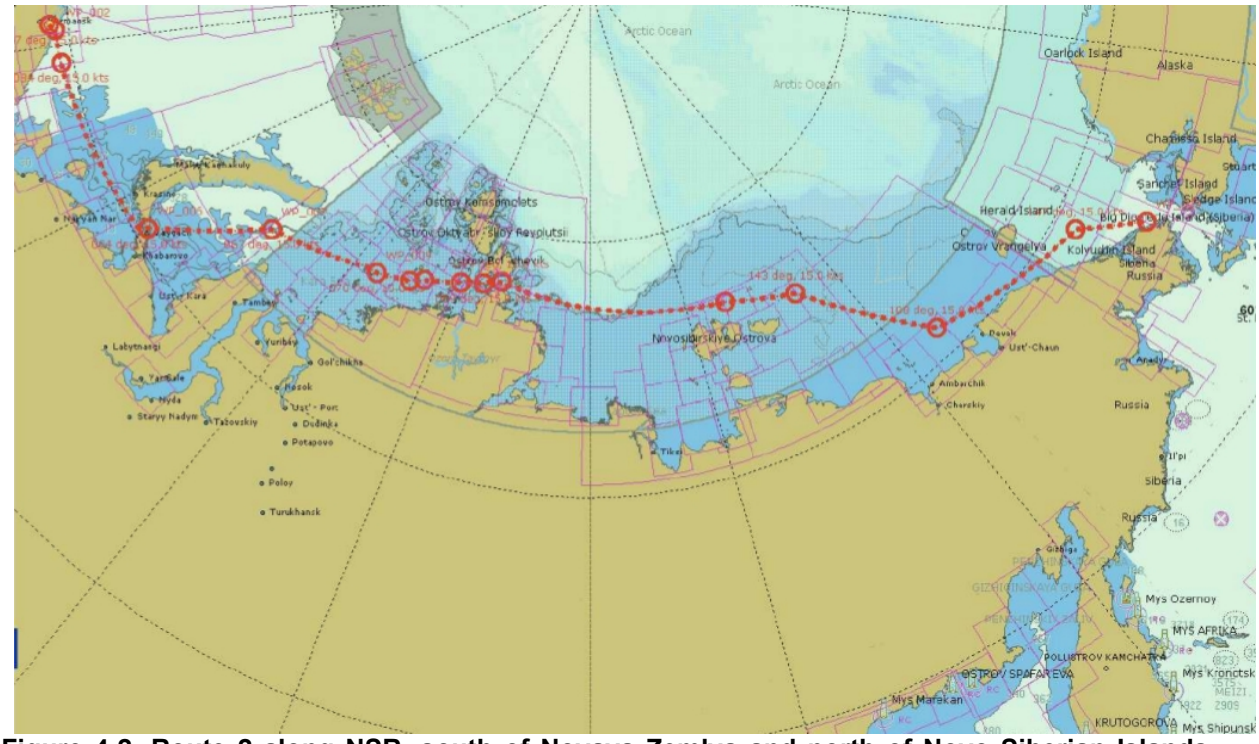

Figure 4-2. Route 2 along NSR, south of Novaya Zemlya and north of Novo Siberian Islands *(Nils Reimer, HSVA)*

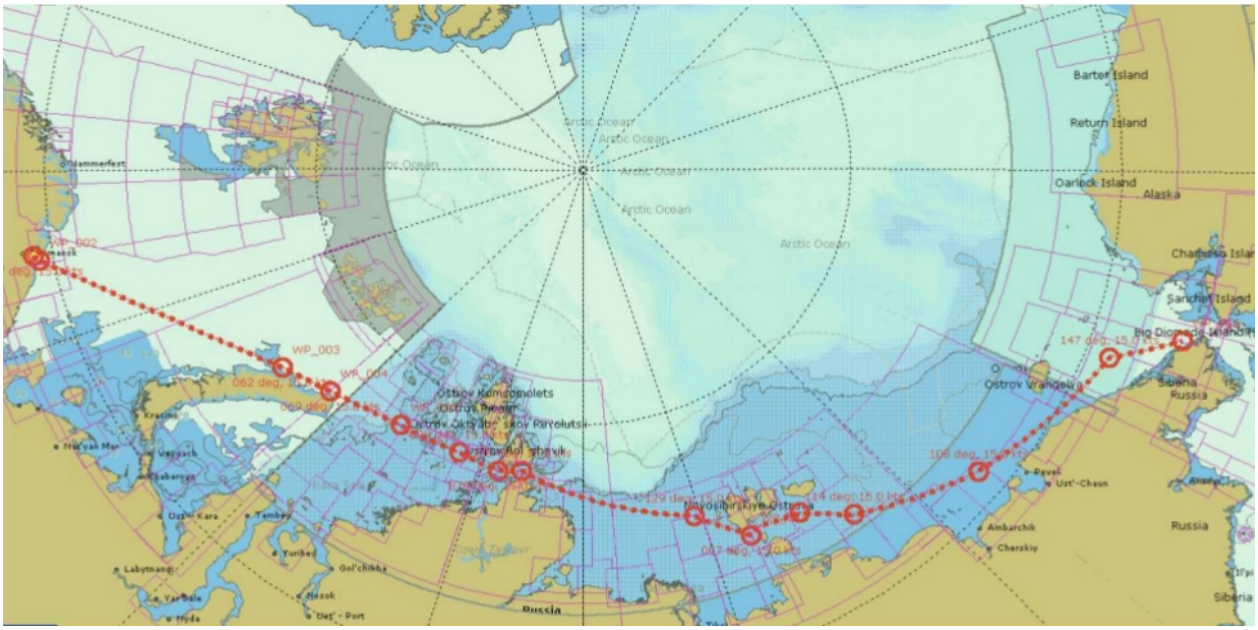

Figure 4-3. Route 3 along NSR, north of Novaya Zemlya and south of Novo Siberian Islands *(Nils Reimer, HSVA)*

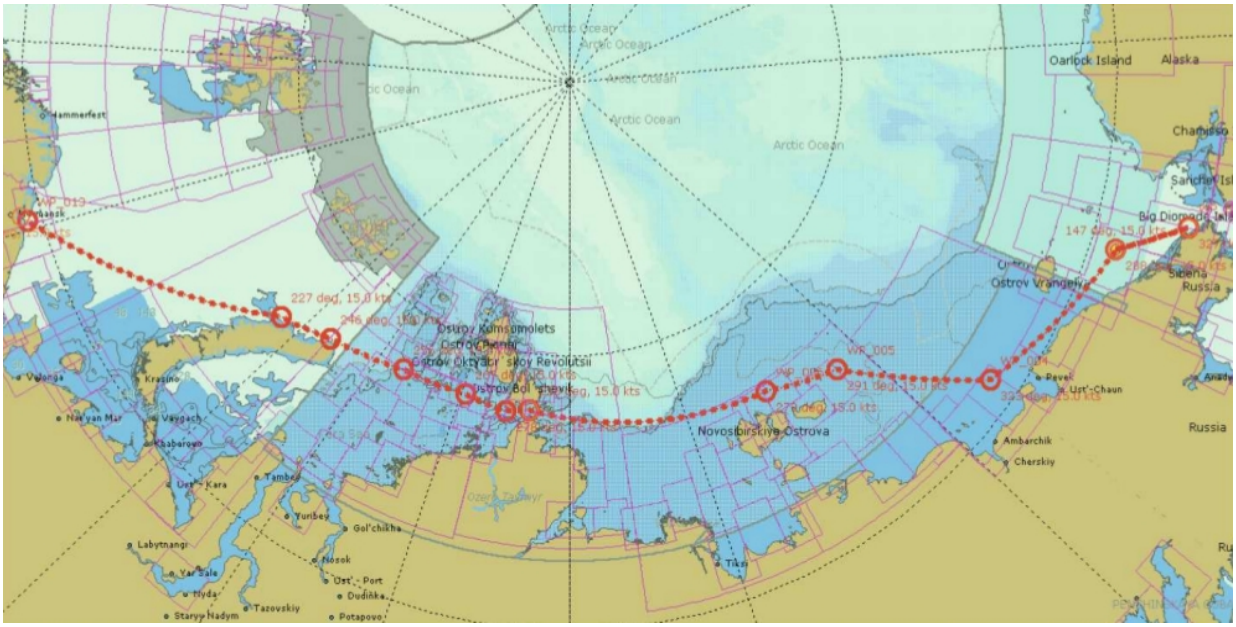

Figure 4-4. Route 4 along NSR, north of Novaya Zemlya and north of Novo Siberian Islands *(Nils Reimer, HSVA)*

Pages 17-19 of the ACCESS D2.42 report presented the three vessels modelled with the ETA HSVA model through ice along the NSR transects which included a bulk carrier, tanker, and container vessel. Ice conditions were taken from a consistent archive of sea ice conditions from the National Ice Center. Based on the minimum extent of sea ice in 2007 compared to 2000, the optimal route to take was Route 1 (which is the longest route) due to conditions of sea ice and performance of all carriers. The container vessel had the highest icebreaking capability and values and the tanker proved to be the the weakest in this simulation. The decreasing ice extent is expected to cause a decrease in travel times but the carrier vessel exhibited the best capabilities to transit during the freeze-up period. Outcomes from the report recommended that climate model scenarios be performed in between the

years 1950 and 2040 to investigate long-term trends in Arctic shipping with a special focus on the NSR.

5. Summary of Arctic ocean-sea ice downscaling runs for CMIP5 climate models along Northern Sea Route

As described in ACCESS report ***D1.51 – "Results of Arctic ocean-sea ice downscaling runs validated and documented*** (https://wiki.met.no/_media/access/deliverables/d1-51-awi-final.pdf) AWI tested the following four climate models to determine which CMIP5 models perform best in regions by comparing the mean simulated seasonal cycle of monthly mean sea ice concentration (sic) from the historical CMIP5 experiment (1850-2005), with those from satellite derived sea ice concentrations for the available period of observation. The models MPI-ESM-LR, GFDL-CM3, NorESM1-ME, and the CCSM4 were compared to observations from the past, thus inferring the best capabilities for its performance in the future. The data was retreived from the Earth System Grid Federation (http://pcmdi9.llnl.gov/esgf-web-fe/) for the areas in Figure 5-1:

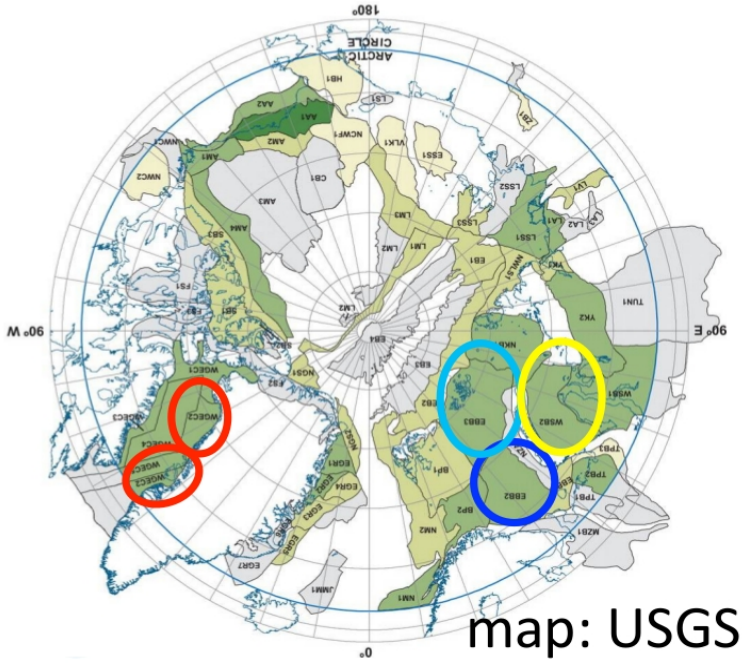

Figure 5-1. CMIP5 model comparisons for specific regions in the Arctic to test best performance for sea ice concentration. (*Reiman-Campe, K, AWI)*

The MPI-ESM_LR proved to provide the best indication of sea ice concentration over the whole Arctic and regionally when compared to the others for sea ice concentration in the past. This was subsequently applied in a downscaling experiment for the reason that a higher resolution regional coupling with an ocean-sea ice model is expected to show a better result for sea ice concentration because it has improved representation of sea ice and ocean processes.

The downscaled simulation with satellite derived SIC and SIT shows that the downscaled simulation produces more and thicker ice than the original MPI-ESM-LR and is closer to satellite observations than the CMIP5 model. They produced a map going along the NSR following the same trajectory as modelled by HSVA (except the area through the Siberian Islands), and calculated the number of days where the sea ice concentration was <20% and

< 1.5m sea ice thickness, a certain threshold that ships can navigate. In general, the downscaling simulation showed that areas on the route route east of the Vilkitsky Strait and/or east of the Dmitry Laptev Strait, may always be difficult to traverse through, while the straits themselves are mostly open for more than 80 days during the year and approximately 50-70 days in some parts of the Laptev and Siberian Seas (Figure 5-2). Additionally, the areas along the coast are showing thinner ice.

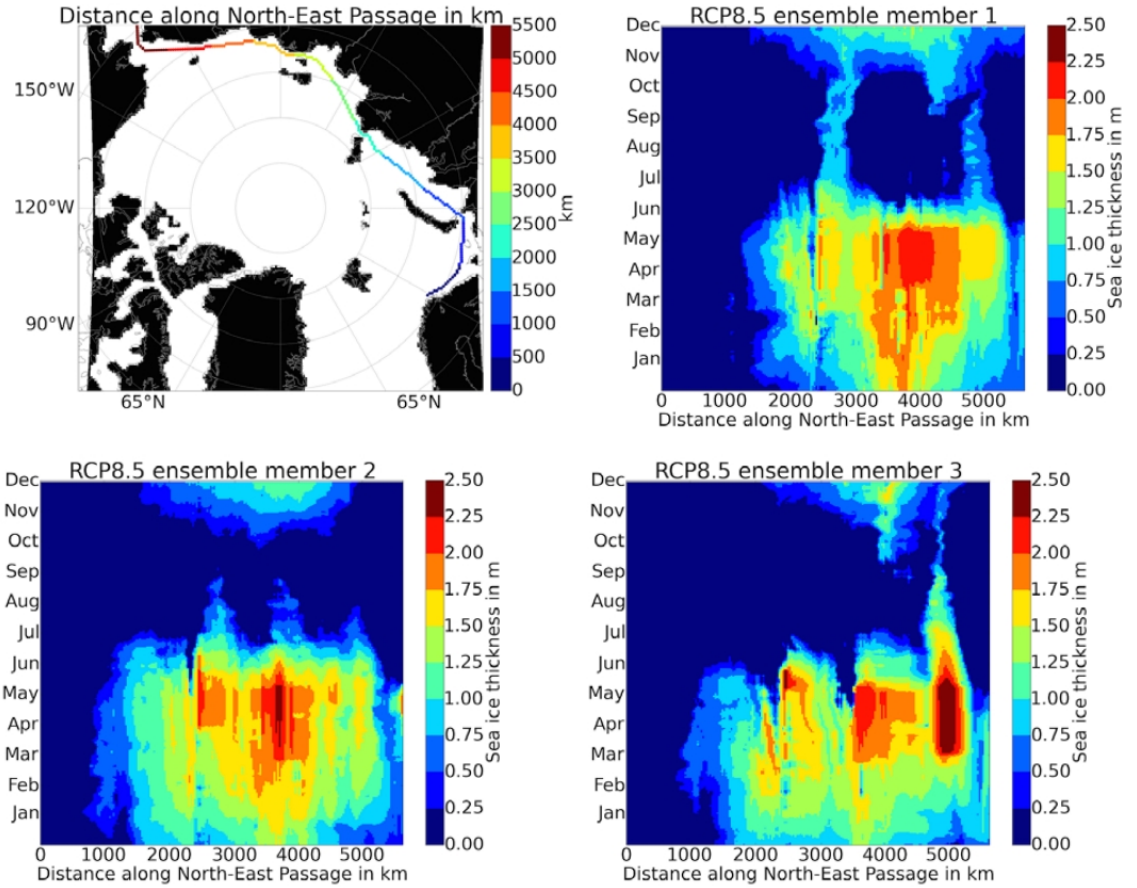

Figure 5.2. Northeast Passage trajectory (upper left) and daily sea ice thickness distributions along the Northeast Passage during 2040 for individual ensemble members. All results are from downscaling experiement 8.5. (*Reiman-Campe, K, AWI)*

Though these models do provide some indication of what we can expect with sea ice concentration for future scenarios, their inaccuracies can be influenced by environmental factors that are difficult to parameterize such as sea ice pressure ridges, oscillations in atmospheric systems, ocean forcings, etc.

6. Updated information for ACCESS Survey

Based on the recent outcomes regarding expected sea ice conditions in ACCESS, it is important to get updated feedback on the previous survey which described the general need of sea ice information from users. The following survey in Appendix A will not include general background information found in the first survey, but will reflect what we know about sea ice in the Northern Sea Route and get an idea of how we can improve how we are disseminating this information for navigators. This survey will request information regarding the NSR solely based upon sea ice and environmental conditions.

Appendix A – Questionnaire Assessment of Future Monitoring and Forecasting Based on Scenerios

Part I: General Information (check all that apply)

Your Name: _____
Name of Organisation: _____
Email: _____
Telephone: _____

What area is your organization involved in?

- ☐ Fisheries
- ☐ Air Logistics
- ☐ Government Environmental
- ☐ Oil/Gas
- ☐ Government/Inspection
- ☐ Tourism/Adventure
- ☐ Research
- ☐ Insurance
- ☐ Shipping
- ☐ Fierries
- ☐ Wildlife
- ☐ Other (please explain):

What main routes in the Arctic do you travel through the most?

- ☐ Northwest Passage
- ☐ Northern Sea Route
- ☐ Transpolar Sea Route
- ☐ Arctic Passage
- ☐ Other (please explain):

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, e.g. for data retrieval or temporal integration
- ☐ Information integrated with existing user data
- ☐ Other (please explain):

Part II: Tactical and Long-Term Strategic Planning (check all that apply)

How far ahead do you need to plan your routes through the Arctic?

- ☐ Within days
- ☐ Within weeks
- ☐ Within months
- ☐ Within years
- ☐ We plan our routes depending on the area and operation
- ☐ Other (please explain):

What sources of sea ice information do you currently use to plan your future paths through the Arctic?

- ☐ Sea ice charts
- ☐ Most up-to-date satellite imagery
- ☐ Historical sea ice information
- ☐ Inherent knowledge of sea ice
- ☐ Sea ice models
- ☐ Communication with local knowledge
- ☐ Other (please explain):

What types of information do you need before planning future voyages through sea ice infested waters?

- ☐ Most up-to-date satellite imagery
- ☐ Historical sea ice information
- ☐ Inherent knowledge of sea ice
- ☐ Sea ice models
- ☐ Communication with local knowledge
- ☐ Sea ice concentration
- ☐ Sea ice thickness
- ☐ Information on pressure ridges
- ☐ Other (please explain):

What specific information are required if you need to make any changes to your planned trajectory and traverse through the Northern Sea Route?

- ☐ Higher spatial/temporal resolution satellite data
- ☐ Sea ice concentration forecasts up to 1-3 days
- ☐ Sea ice concentration forecasts up to 3-5 days
- ☐ Sea ice concentration forecasts up to 2 weeks
- ☐ Sea ice concentration forecasts > 2 weeks
- ☐ Sea ice thickness forecasts up to 1-3 days
- ☐ Sea ice thickness forecasts up to 3-5 days
- ☐ Sea ice thickness forecasts up to 2 weeks
- ☐ Sea ice thickness forecasts > 2 weeks
- ☐ Other (please explain):

Do you have a choice in the routes you take?

- ☐ Yes
- ☐ No
- ☐ Other (please explain):

Do you have a choice to respond to forecast conditions?

- ☐ Yes
- ☐ No
- ☐ Other (please explain):

What do you think is the most important difficulty of navigating through sea ice?

- ☐ Sea ice concentration
- ☐ Sea ice thickness
- ☐ Sea ice pressure ridges
- ☐ Sea ice stage of decay
- ☐ Lack of navigator knowledge of sea ice
- ☐ Other (please explain):

Based on near future predictions there is optimism that the amount of cargo being transported through the Northern Sea Route will significantly increase, as an alternative to the Suez Canal. If this is an option, how far in advance could you plan to reconfigure your route through the NSR instead of the Suez Canal if is shown to be more cost effective?

- ☐ Within days
- ☐ Within weeks
- ☐ Within months
- ☐ Within years
- ☐ We don't have that option
- ☐ Other (please explain):

During 2007 and 2012 the Arctic experienced lower sea ice concentration coverage than what was experienced in 2014. The amount of cargo shipped along the Northern Sea Routhe was also 77% less in 2014 than in 2013. This suggests the current state of sea ice estimates in the future may be more dynamic than expected. Does this affect how shipping routes are planned for 2015 and 2016?

- ☐ Yes
- ☐ No
- ☐ Maybe
- ☐ Doesn't matter

If answered "No" or "Maybe," please provide an explanation of how current environmental changes in the Arctic Ocean along the Northern Sea Route influence your future planned trajectories (optional).

The most efficient Northern Sea Route, based on the Estimated Time of Arrival (ETA) algorithm, is mapped out for south of Novaya Zemlya and south of New Siberian Islands. How helpful is this information to you?

- ☐ Very helpful
- ☐ Somewhat helpful
- ☐ Not helpful
- ☐ Not helpful because it's not clear
- ☐ We are unable to use this information for future planning because we do not have any choice in future directives
- ☐ Other (please explain):

Overall, can you use information on future predictions of sea ice in the Arctic (i.e. climate models and shipping estimates based on ice conditions in the future)?

- ☐ Yes
- ☐ No

Part III: Uses of Climate Change Information Section (check all that apply)

Do you have confidence in climate models?

- ☐ Yes
- ☐ No
- ☐ I don't know enough to provide an answer

If "No," why not?

- ☐ Incorrectly communicated to the public
- ☐ Lack of uncertainty estimates in models
- ☐ Not enough information about influential factors incorporated into models
- ☐ Lack of user knowledge
- ☐ Other (please explain):

How would you use sea ice climate model data to assist your future initiatives?

- ☐ Strategic planning
- ☐ Long-term forecasts
- ☐ Incident prevention and response
- ☐ Funding opportunities
- ☐ I do not use them because they do not contain enough information
- ☐ Other (please explain):

The climate models predict that the Straits along the Northern Sea Route will be open approximately 80 days within the year 2040. How does this information affect your needs?

- ☐ Helpful for long-term planning
- ☐ Helpful for collaboration with scientific communities
- ☐ Helpful for future recommendations when planning for ship requirements
- ☐ Does not have any effect
- ☐ Other (please explain):

Regarding the new model outcomes on the Northern Sea Route from climate models and a cost analysis, what factors need to be included to make this effective for you?

How do the future climate scenarios from ACCESS and cost analysis schemes for specific categories of ships affect future design planning of transport vessels?

- ☐ They influence future planning design
- ☐ They do not provide enough information for what is needed for navigation
- ☐ They have no effect
- ☐ Other (please explain):