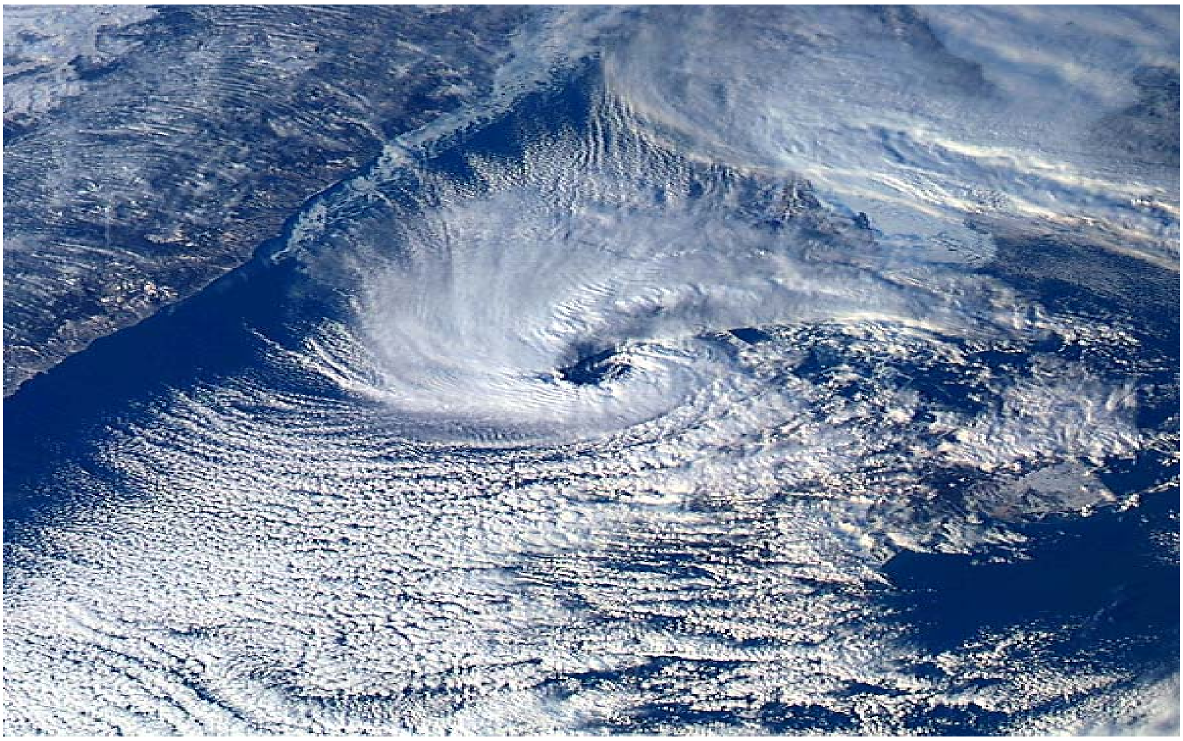
BLUE ACTION

End-user Requirements Specification Report

Blue-Action Case Study Nr. 3



Picture 1 Polar low. Photo courtesy of O. Aarnes

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About this document

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Lead authors
DNV GL: Øivin Aarnes & Kazuyoshi Mori

Contributing authors
DNV GL: Morten Mejlænder-Larsen

Reviewer
Danish Meteorological Institute: Chiara Bearzotti

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Summary for publication

Sailing in the Arctic requires vessels and crew to be prepared for encountering unexpected conditions. The mere nature of the Arctic, as pristine and desolate as it can be, is changing. With climate change, in all its' manifestations, the world is witnessing altered weather systems, declining ice extent, warmer polar waters, and changes in the way storms form and develop. **Cold air outbreaks and polar lows are weather phenomena which are hard to predict.** They depend on a certain set of conditions being present, and they can form and dissipate rapidly. The Arctic is becoming more accessible, and consequently, the world will likely see increased commercial activity in polar waters in the next decades. Russia is already investing heavily in the Arctic, and the United States, Asia, Europe and Canada, are all present in emerging Arctic trade and operations. This brings on new challenges and risks, not only for ships that sail these waters, but for the Arctic environment, and for those who depend on it.
Understanding the impacts of a changing Arctic, and its linkages to lower latitude climate is high on the agenda in the maritime community as well as in tourism, fisheries, and oil and gas industries.

IMO has adopted the **international code for ships operating in polar waters** (**IMO Polar Cod**e) and related amendments to make it mandatory under both the International Convention for the Safety of Life at Sea (SOLAS) and the International Convention for the Prevention of Pollution from Ships (MARPOL). The revised Polar Code went into force on **1 January 2017.** With the adoption of the **IMO Polar Code**, all ships operating in the Arctic must comply with the code. This sets a new standard for safety of navigation and requirements for environmental protection. The overarching goal of the code is to **provide for safe ship operation and protection of the polar environment by addressing risks present in polar waters and not adequately mitigated by other instruments of the organization.**

In Blue-Action, DNV GL is **investigating business opportunities** which may arise from valuating climate services. Polar lows exhibit a certain type of risk to Arctic operations. **The present report outlines a risk-based approach for dealing with these risks.**
The approach aims to:

- investigate means of improving our awareness towards extreme weather formations, and
- give notion to how the maritime industry can better utilize forecasts on severe weather impacting on safety, efficiency, and sustainability.

In this setting, this report summarizes **current needs and findings towards embedding forecasts of polar low formations into risk advisory, and including extreme weather forecasts in general.** Needs have been identified in customer meetings, internal workshops, through consulting maritime experts, and communication with external stakeholders. The project recognizes there are knowledge gaps in understanding polar lows, how they develop, and the mere feasibility in their prediction.

Work carried out

The focus of work conducted by DNV GL in this phase has been to identify use cases applicable to our study, and to assess business value related to these. The continued work, i.e. deliverables of WP5 relate to-, and depend on- deliverables from WP1 model implementation, assessment of predictive skill, and WP4 qualification and transfer of data relevant to the study.

To aid the requirements process, the study has conducted activities:

- Internal workshops on identification of possible use cases
- Needs assessment with regards to data and methodology
- Collaboration with INTAROS on integration of observing platforms
- Data screening on applicable and feasible supporting sources
- Established contacts with the shipping industry in Japan, NiPR
- Clarifications on impact of polar lows on maritime activities
- Risks identification and mitigating options.

Who are the users

The study targets different user groups representing different perspectives and user needs. External stakeholders such as authorities and regulatory bodies might benefit from deeper understanding of ongoing Arctic changes, and act to promote sustainable practice among businesses operating in polar waters. The Norwegian Maritime Authority and the Norwegian Coastal Administration have called for work that enables scientifically sound judgement on impact of climate changes in polar waters. Among businesses, the project has identified Japanese and Norwegian ship-owners, oil and gas operators, and fisheries as key interest groups. Fisheries include coastal fisheries, aquaculture, and fish farm owners and operators.

Picture 2 Photo courtesy of O. Aarnes

Needs Assessment

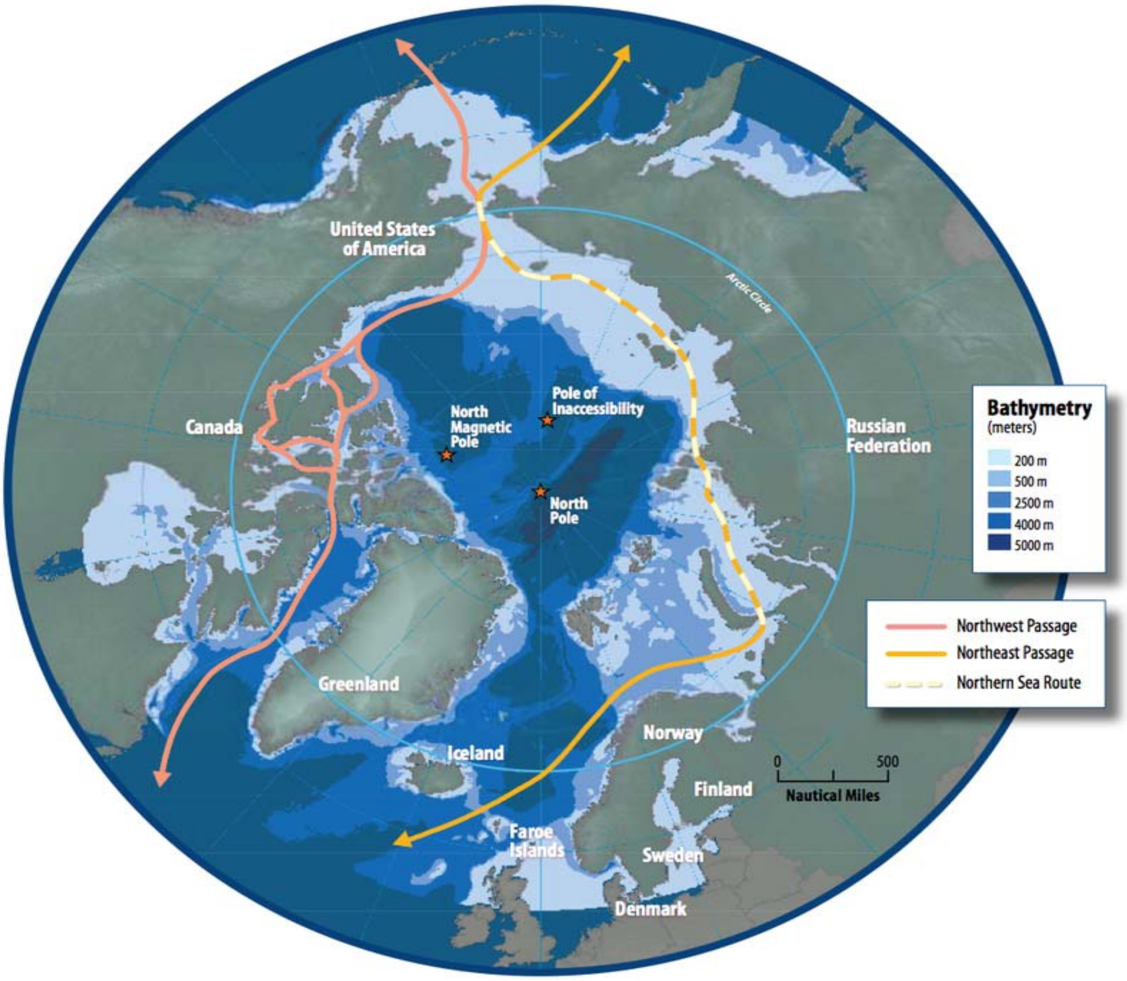
The Arctic is not a uniform environment, and needs with the industry must be understood considering environmental diversity and geographical coverage. Safe and sustainable shipping, for instance, must be considered in context of location and the nature of operation. This calls for a broad understanding of the risks involved. Risks in the Arctic can arise from lack of communication, remoteness, limited search and rescue capacity, severe weather, darkness, low temperatures, sea ice and icebergs, a sensitive environment, and an array of other factors which all influence on the risk picture.

For a normal vessel, a polar low may cause severe icing unless precautionary action is taken, but apart from that, the vessel should be designed to withstand winds and waves resulting from polar lows. This means that when operating in polar waters, one should always prepare for running into a polar low. Except from possible icing and unpleasant conditions onboard during the storm, the vessel is designed to remain intact. There are several ways to reduce impact from severe icing. Examples of mitigating action include reducing speed and adjusting heading to minimize sea spray. For experienced masters, this is generally not a big problem. It should be noted however, that special operations requiring calm weather and steady sea state, are more vulnerable to the impacts of polar lows. Hence, polar lows represent an additional risk in circumstance, and forecasts are useful.

To understand distribution of polar lows, a first step is to look at past known occurrences. By compiling historical data on events, and qualifying areas of higher affinity, these can be mapped to serve as a baseline risk layer. In addition, the study needs a concise means of classifying polar lows, or polar storms in general, in terms of air pressure, winds, Sea surface temperature (SST), and/or precipitation measures. Scale and severity is of importance, as this helps distinguishing major and minor outbreaks, along with their connectivity with driving factors such as polar vortex configuration. The study needs hindcast reanalysis data representing the last decade for this purpose.

Considering sub-seasonal to seasonal forecasts, the project recognizes that predicting polar lows beyond the synoptic scale is hard, if not impossible. However, as the environment, in which they form, i.e. outbreaks of Arctic air masses over warm ocean surfaces, may be predictable on seasonal to seasonal (s2s) time scales, the study would like to focus on mapping these larger-scale features to serve as a forecast layer. In this regard, our case study will need consolidated s2s gridded forecast datasets on ocean temperature (SST) and air temperature (T_{10}). An important subtask of Blue-Action WP1 is to assess and quantify empirical relationships between large-scale atmospheric and lower boundary (ocean surface, sea ice) drivers and polar lows. If a relationship or correlation with polar lows can be drawn from this, the study will pursue including this into the risk model. The goal is to provide early warnings to ships based on pressure systems, sea surface temperature, polar front development, and cold air outbreaks.

Improving safety to shipping is critical in the Arctic. Ships sailing the North-East passage (Northern Sea-Route) may encounter polar lows, and for this reason, we need to understand the causal mode of this weather phenomenon.



Picture 3 Accessible via https://en.wikipedia.org/wiki/Northeast_Passage

Operational risks

As prescribed above, our study targets Arctic shipping, fisheries, and oil and gas operations. In context of operation, these industries perform different activities at sea, and each activity is associated with some level of risk. Ship-to-ship transfer (STS) is an activity, which implies a vessel transfers its' cargo to another. A large crude oil carrier (VLCC) may need to transfer cargo due to draught restrictions at port. The operation is quite complex, and a smooth, safe, and timely transfer requires- amongst all- a weather window, which is suitable and within operational limitations.

Examples of maritime risks:

- Grounding
- Collision with installation
- Collision during ship-to-ship (STS) approach
- Accidental oil spill during loading/unloading.

Sources of hazards

The Polar Code considers hazards which may lead to elevated levels of risk due to increased probability of occurrence, more severe consequences, or both [3]. Among these hazards, the case study will emphasize:

1) Ice, as it may affect hull structure, stability characteristics, machinery systems, navigation, the outdoor working environment, maintenance and emergency preparedness tasks and malfunction of safety equipment and systems
2) Experiencing topside icing, with potential reduction of stability and equipment functionality
3) Low temperature, as it affects the working environment and human performance, maintenance and emergency preparedness tasks, material properties and equipment efficiency, survival time and performance of safety equipment and systems
4) **Rapidly changing and severe weather conditions**, with the potential for escalation of incidents
5) The environment with respect to sensitivity to harmful substances and other environmental impacts and its need for longer restoration.

Needs from climate services

Considering hazards identified above, a climate service should be designed to meet maritime operational needs. A ship owner will need an updated risk picture for the next voyage in the wake of heavy icing, tourists visiting Svalbard in January may want to avoid the blizzard, and the fish farm owner wants to secure his compounds prior to the storm. These interests drive requirements for climate services, and the information they carry. Firstly, they relate to the kind and quality of data delivered through the service, and secondly to the mechanism of transfer and ease of uptake. For obvious reasons, a service needs to convey information *fit-for-purpose*, and it needs to deliver timely and consistently. To be specific, mitigating the impacts of severe weather will require a climate service to deliver information that is readily recognized as useful, without the inherent complexity in communicating weather. Information carried through the service must bridge climate science by translating weather [the polar low] into operational impact and risks. A ship running into a polar low in the Sea of Japan, will want advice on which direction the storm is taking, or how best position the ship to reduce the impact of icing.

The outcome from this case study will be a service for clear communication of risks associated with polar lows. It is envisioned that such a service can be used in operational risk reduction, and advisory to maritime operations.

DNV GL customers need to understand the implications of extreme weather on their operations. The study will propose a product including the following features:

- Timely (monthly) risk picture incorporating polar lows as a risk driver
- Key operational risks distributed to specific areas and operations
- Icing predictor resolved from forecast of winds, temperature, and sea surface temperature

To assess applicability, the following criteria may be advised:

- Critical factors for navigation and safety at sea
- History of accidents in polar waters
- Patterns in formation and trajectory of polar storms
- High risk areas for polar lows, i.e. Sea of Japan
- Main fairways in Arctic shipping
- Implications of the IMO polar code

In the process, we have identified and consulted the following preliminary data sources:

Source	Record/Reanalysis/Forecast	Variable/Parameter
WOAD	Historical records of offshore accidents and incidents	Chain of events, causes and consequences
ERA-INTERIM	Reanalysis data	Precipitation, Air Temperature
ECMWF	Operational forecasts, seasonal forecasts	EFI, Winds, Precipitation
ASR NCAR/UCAR	Reanalysis data	Precipitation, SST, Air Temperature, Surface Pressure, Winds
Copernicus/MEMS	Seasonal forecasts/In-Situ	Winds, Sea ice, SST
MET/Barents Watch	Barents Watch portal – polar lows	Polar Lows (Barents Sea)

Other data needs

The risk methodology proposed in this report will facilitate inclusion of additional risk drivers. The study will benefit from a more comprehensive view on where activity is high or low, and thus exploiting the value of providing risk advisory in the region. The study is considering including AIS data to give an account of traffic in the region, and environmental data to infer environmental consequences from incidents such as oil spills.

Data on known activity and sensitive areas in the Sea of Japan and the Barents Sea:

- AIS traffic data representing ship tracks for selected class and type – container, tankers, fishing vessels
- Marine protected areas; fishing grounds, spawning areas
- Environmental sensitive areas; Particularly Sensitive Sea Area (PSSAs).

Main results achieved

The following main results have been achieved during the implementation so far.

Understanding polar lows

The polar low refers to a weather phenomenon which arises from low pressure systems forming over open waters poleward of the main polar front. A polar low is a small-scale, short-lived atmospheric low pressure system (depression) engendering strong winds and heavy precipitation. A polar low is much like a subtropical cyclone, but driven by Arctic pressure systems; the polar vortex, and cold air outbreaks over open warmer waters creating a funnel of rising relatively humid air. This system acts as a convective pump fusing heat into upper atmospheric boundary layers. A marine polar low is often accompanied by strong winds, heavy precipitation, cold temperatures, marine icing, and rough sea states.

About model results

Model results are expected outcome from dynamic/statistical modelling activities conducted in the Blue-Action WP1, Task 1.5. The study will promote results based on these outputs. Hence, a key activity will be to translate model results into useful information layers applicable for risk assessment. The study requires results to be presented in such a way, that they can easily be incorporated in risk analysis and mapping. The risk-based approach is described in chapter Risk assessment methodology. All datasets must conform to the climate and forecast (CF) convention of NetCDF files.

Defining the product

The study aims to present results as a separate risk layer in the Arctic risk map. The inherent complexity of weather [polar lows] on one hand, risk driving factors, and the geographical distribution of shipping on the other, calls for an approach which encompasses risk variability in space and time. For sake of ground truthing and promoting uptake with selected clients, the study would like to focus on two specific cases, one in the Sea of Japan, and one in the Barents Sea.

Risk assessment methodology

As described previously, the unpredictable polar low associated with strong winds, heavy precipitation, etc., generates negative impact on activities at sea. Maritime endeavors such as container shipping, cruise, and fisheries are all affected by weather. Oil and gas operations need regular support from offshore supply- and maintenance vessels (OSV/PSV[1]). When approaching facilities, these close encounters constitute a risk to people and assets. Assets such as drilling rigs, floating- production, storage, and offloading units, all engage with ships at some point. Any accident, either it is injury or fatality of people on board a vessel, or any negative impact posed on the environment, is normally termed as "Consequence" in oil & gas, and maritime industry.

Risk from an event is defined as the product of "Probability" (sometimes Frequency or Likelihood) and "Consequence (or Severity)". A semi qualitative method to determine the risk level (Low, medium and High) is illustrated in Figure 1. This should be adjusted to fit the purpose.

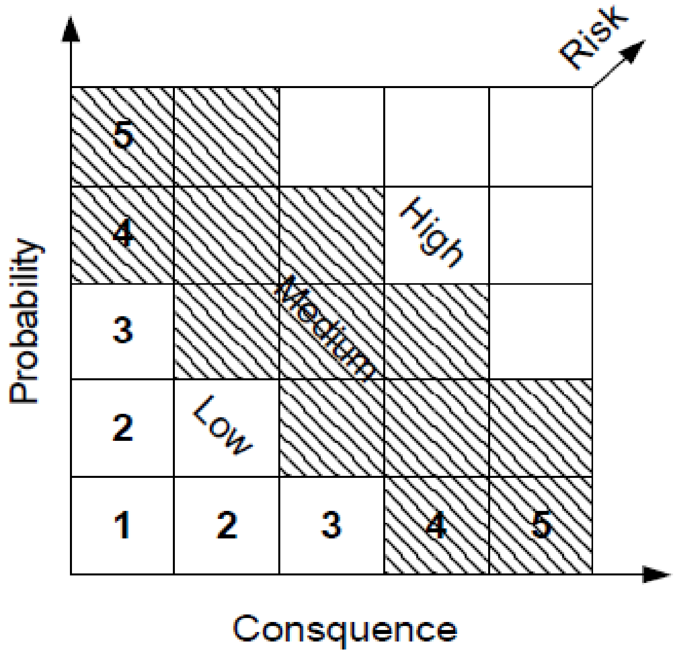


Figure 1 Risk matrix

The consequence has several elements to be evaluated. It is normally evaluated against all or one of these elements:

- People (safety)
- Environment

[1] Offshore Support Vessel/Platform Supply Vessel

- Asset (production loss or delay)
- Reputation (of owner or operating company).

When it comes to "Probability/likelihood" of polar low risk, it is obvious that no polar low occurrence, no polar low risk. Hence, "Probability/likelihood" of polar low risk should be based on WP1 feasibility study of polar low forecast (To be confirmed).

The study suggests using the following matrix to evaluate risks to people (safety) and risks to the environment for this project.

			Probability				
Consequence			1	2	3	4	5
	People	Environment (Fisheries)	Incident is not expected (< 1E-4)	An incident has occurred in industry or related industry (1E-4 < P < 1E-3)	Has been experienced by most operators (1E-3 < P < 1E-2)	Occurs several times per year per operator (1E-2 < P < 1E-1)	Occurs several times per year per facility (1E-1 < P)
1	No or superficial injuries	Slight effect on environment < 1 BBL (barrel of oil)	L	L	L	M	M
2	Slight injury, a few lost work days	Minor effect Non-compliance < 5 BBL	L	L	M	M	M
3	Major injury, long term absence	Localized effect Spill response required < 50 BBL	L	M	M	M	H
4	Single fatality or permanent disability	Major effect Significant spill response <100 BBL	M	M	M	H	H
5	Multiple fatalities	Massive effect damage over large area >100 BBL	M	M	H	H	H

Figure 2. Suggested risk matrix

Note on risk matrix

The project will review and assess risk criteria through the continuation of the project. The study anticipates industry workshops will provide important feedback to cause and effect scenarios. These learnings allow for calibrating probability and consequence categories, and the people, ships, and assets affected. Since the nature of an event and its' consequences vary, different risk criteria apply when assessing fisheries opposed to assessing the maritime industry. The consequence to a fleet of fishing vessels can be severe while the consequence to a VLCC in transit is minor. Hence, the matrix will be revised after learning from workshops. Two workshops are planned in project month 48: Deliverable D5.14 "CS3 End-user workshop on polar lows prediction Japan" and D5.15 "CS3 End-user workshop on polar lows prediction Norway".

Mapping methodology

“Probability/likelihood” and “Consequence” of polar low risk mapping can be expressed with layer concept as shown below. The proposed methodology allows for fine-grained and realistic consequence assessments which can be translated into a concerted risk picture.

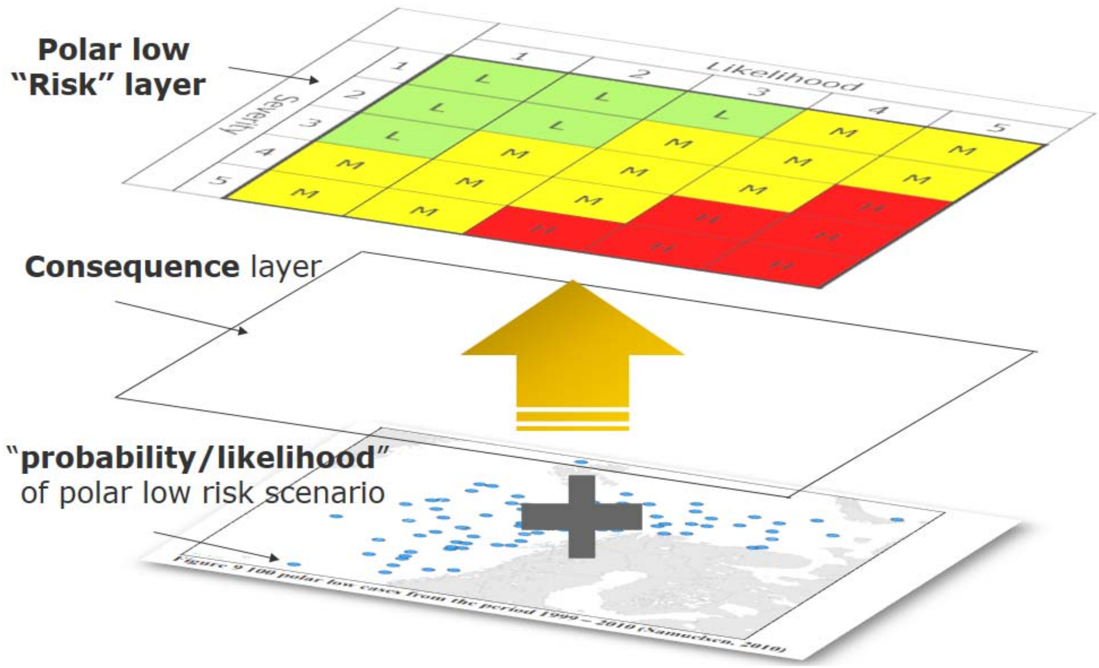


Figure 3 Risk mapping based on layer consept

As shown below, “Probability/likelihood” of polar low risk is based on statistical data of polar low occurrence. In this example, “Ship cargo traffic” constitutes the consequence layer.

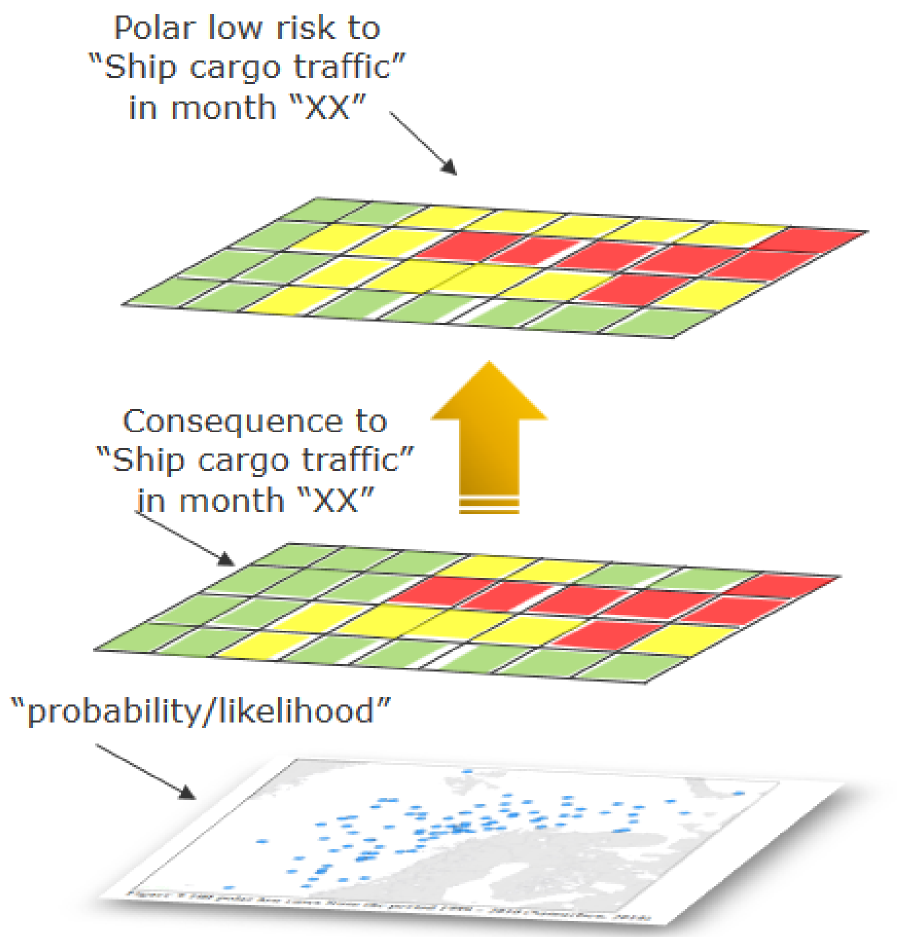


Figure 4 Polar low Risk mapping based on probability and consequence layer (ship cargo traffic) in month XX

It is noted that risk differs by season and month due to variations in ship traffic and distribution in polar low data, hence the above risk map should be updated every season/month.

It can also be a situation, where you need to know the total risk picture considering all possible scenarios. For this case, a consequence layer can be added and integrated with another to create a balanced consequence scenario. The below risk mapping illustration represents a “ship traffic cargo” and “fisheries” scenario as integrated into “polar low risk” mapping.

Selection of consequence layers should be based on the needs of users.

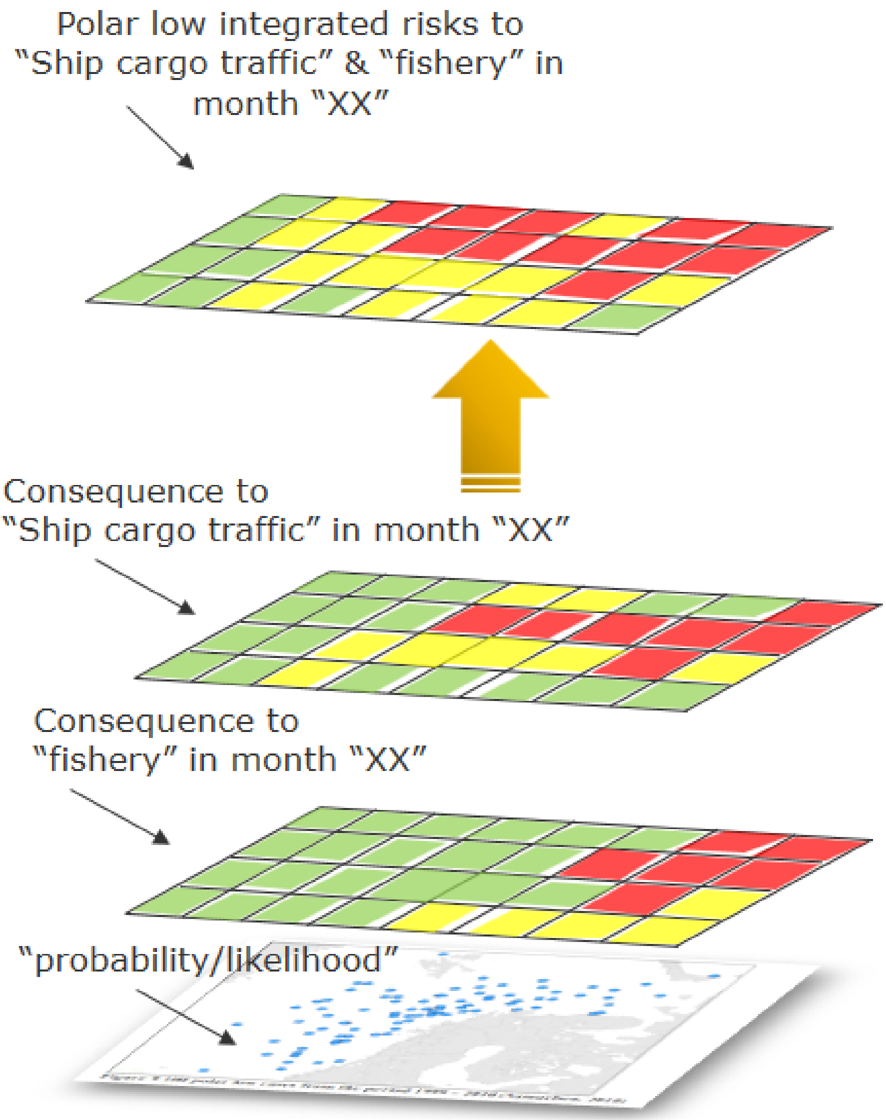


Figure 5 Polar low Risk mapping of ship cargo traffic and fishery in month XX

Progress beyond the state of the art

Dynamic risk assessment, barrier management, uncertainty assessments, and ready integration of online climate information contribute to progress beyond what is typically recognized as state of the art in risk management and advisory.

There are several aspects to dynamic risk advisory, but a common denominator is that the industry is moving into ever more digitalized and autonomous operations. Sensors aboard ships and satellite tracking (AIS) allows for a continuous feed of information on the ships performance and risk exposure. As part of this study, DNV GL investigates a basis for leveraging climate services into this space, and to simplify the uptake of risk-based decision support grounded in climate science.

Impact

<u>How</u> has this work contributed to expected impacts of Blue-Action?

By raising awareness towards needs, and outlining a practical and feasible model for risk assessments, while at the same time incorporating vital climate information, this work contributes to assessing needs, and business value, from a maritime climate service. The industry is seeking ground truthing of its' decisions on future operations, and with risk assessment of its' operational and planned activity, the maritime sector improves its' capacity to respond and adapt to unforeseen impacts of climatic change.

Impact on the business sector

As described previously, this report aims to clarify and summarize needs identified with the business sector on leveraging climate services into daily operations. While our case clearly addresses the maritime and oil- and gas industries, it should be noted that efficient communications and increased collaboration in the North will eventually serve a mutual benefit among all. With adoption of integrative and up to date climate information serving a specific purpose and context, players will be informed when they need to. Increased connectivity and transparency in decisions will eventually foster sustainable business action.

Lessons learned and Links built

Through the course of the project we have learned that access to data is difficult. The case study is dependent on deliverables in Blue-Action WP1, specifically with respect to data relevant to mapping of polar lows, and it has proven difficult to aquire these.

Links are built with theH2020 project INTAROS project through direct participation in dissemination activities, and through explorative research towards needed datasets, and observing networks.

Links are build with Blue-Action WP8, WP5, and WP6 specifically towards dissemination and uptake of climate services.

The study was presented at the Arctic Circle 2017 together with Climate-KIC Aps. The study has enjoyed this collaboration, and will pursue continued support on product development and valuation of climate services.

Contribution to the top-level objectives of Blue-Action

This deliverable contributes to the achievement of the following objectives and specific goals indicated in the Description of the Action, part B, Section 1.1: http://blue-action.eu/index.php?id=4019

Objective 5 Optimizing observational systems for predictions

Through collaboration with the H2020 INTAROS project, the study has identified synergies with the Blue-Action project. Observational data on severe weather will be key to ground truthing predictions, and for the remainder of the project the case study of polar lows will follow developments on INTAROS for a possible inclusion of data sources which enable an improved risk model.

Objective 7 Fostering the capacity of key stakeholders to adapt and respond to climate change and boosting their economic growth

A main objective of this case study is to improve capacity of oil and gas-, and maritime businesses, to respond and act on climate hazards and mitigate the risks.

Objective 8 Transferring knowledge to a wide range of interested key stakeholders

With improved prediction of extreme weather in the Arctic, along with better understanding of how these weather phenomena origin, develop, and surface-, the maritime industry can take precautionary actions to mitigate risks associated with extreme weather. With an updated risk picture grounded in state of the art scientific developments on severe weather forecasts, operations in polar waters become safer, more sustainable, and ultimately more economically viable.

References

1. DNV-RP-A203, 2013: Technology Qualification. Recommended Practice.
2. IMO, 2016: MEPC 68/21/Add.1 Annex 10: International Code for Ships Operating in Polar Waters.
3. ISO 17776: Petroleum and natural gas industries – Offshore production installations- Guidelines on tools and techniques for hazard identification and risk assessment.
4. DNV GL Maritime, 2016: The Polar Code- Understand the code's requirements to take the right steps for smooth compliance.
5. Hagen, Ø. Et al., 2013: DNV-Adapt framework for risk-based adaptation: A test case for the offshore industry.

Dissemination and exploitation of Blue-Action results

Dissemination activities

This is a summary of the major dissemination activities undertaken so far by DNV GL and other partners of the consortium for the uptake of the contents of the deliverable and of the implementation plan of the case study on the polar lows.

Type of dissemination activity	Title	Date and Place	Estimated buget	Type of Audience	Estimated number of persons reached
Participation to a conference	Arctic Circle Assembly, Reykjavik, Oct. 13-15, 2017. Participant: Øivin Aarnes	Reykjavik (IS), Oct. 13-15, 2017	See DNV GL form C	Scientific Community, policy makers	300
Presentation	Aarnes, Øivin. (2017, October). Climate services and their role in long-term business strategy. Presenter: Øivin Aarnes. Zenodo. http://doi.org/10.5281/zenodo.1064736 at the Arctic Circle Assembly, Reykjavik, Oct. 13-15, 2017.	Reykjavik (IS), Oct. 13-15, 2017	See DNV GL form C	Scientific Community, policy makers	300
Poster	Payne, Mark, Keil, Kathrin, Kolstad, Erik, Ballester, Joan, Mettiainen, Ilona, Vangsbo, Peter, … Olsen, Steffen. (2017). Translating advances in Arctic climate science to climate services across the Northern Hemisphere (Version November 2017). Zenodo. http://doi.org/10.5281/zenodo.1065467	23 November 2017	See form C of partner involved.	General public, policy makers	200
Publication	Dale, Thomas, Miller, Raeanne, Vangsbo, Peter, Mettiäinen, Ilona, Ballester, Joan, Kolstad, Erik, … Nikitina, Elena. (2018, January 18). Climate Service Case Studies Booklet. Zenodo. http://doi.org/10.5281/zenodo.1154792	18 Jan 2018	See form C of partners involved.	General public, policy makers	200

Poster	Miller, Raeanne, Payne, Mark, Keil, Kathrin, Kosltad, Erik W., Ballester, Joan, Lesser, Pamela, & Vangsbo, Peter. (2017). Translating advances in Arctic climate science to climate services across the Northern Hemisphere. Zenodo. http://doi.org/10.5281/zenodo.827081 5-9 June 2017, 3rd European Climate Change Adaptation Conference, Glasgow (UK) Presenter: Raeanne Miller	5-9 June 2017, Glasgow (UK)	See form C of partners involved.	Scientific community and policy-makers	200

Peer reviewed articles
Not applicable for the time being.

Other publications
See the dissemination table above.

Uptake by the targeted audiences
As indicated in the Description of the Action, the audience for this deliverable is the general public.

This is how we are going to ensure the uptake of the deliverables by the targeted audiences
Despite of the PU nature of the deliverable, priority in dissemination will be given to the consortium and Arctic cluster partners:

- This deliverable will be shared with the consortium in the project intranet.
- We plan to share it with the INTAROS project teams and with the EU-PolarNet CSA, for further dissemination to the projects of the Arctic cluster.
- We also plan to share this document the RIAG and SEG advisors of Blue-Action.

For reaching out to the general public, the contents of this deliverable will be taken up by WP8 and disseminated broadly using the social media of the project.

Additionally, the deliverable will be archived in Zenodo for granting open access to larger audiences.

Intellectual property rights resulting from this deliverable
For the time being, we keep on monitoring the development of the work performed by DNV GL and the connection with the Blue-Action WP1: we will check if the IP emerging from the research need to be protected and how with the legal advisors of the organisations involved.