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Indicators for Sustainable Development of Marine Transport and Tourism in the Arctic

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1 Introduction

The aim of this report is the development of a set of indicators that can provide information on the sustainability of Arctic off-shore energy production, especially the production of gas and oil. As we aim to include effects from Arctic off-shore energy production also beyond the energy sector itself, the indicator set is intended to inform about the sustainability of the state and direction of development in the whole Arctic. While this report focuses on measuring the impact of hydrocarbon production, it is embedded in a series of reports on sustainable development indicators in the Arctic that cover shipping and tourism activities, sea food production, and a synthesis addressing cross-sector and governance aspects. This series of reports form part of the synthesis of the European Union Seventh Framework project "Arctic Climate Change, Economy and Society" (ACCESS) together with a marine spatial planning tool, a framework for integrated ecosystem based management and a synthesis report.

The information provided by this report is meant to inform decision makers and researchers concerned with the Arctic. Next to decision support through information, researchers may profit from this indicator set by using the indicators as input or output parameters of models and for designing scenario-based simulation exercises on future developments. The report covers early warning indicators, but lagging indicators as well. The set of indicators proposed is a working document that could be continuously refined after the ACCESS project, based on improved knowledge of the Arctic social-ecological system.

A set of indicators can typically not stand alone, and for decision support in particular it should be complemented with other methods that would help assess whether current development is sustainable, what are the underlying causes of particular changes, whether such changes are reasons for alarm and if so how they can be remedied.

2 Sustainable development in the Arctic Ocean – definition and relevance for decision making

The concept of "Sustainable Development" was coined by the "World Commission on Environment and Development" (WCED) in its final report "Our Common Future", or "Brundtland Report", after the name of the commission's chairwoman, Gro Harlem Brundtland. The report defines Sustainable Development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED 1987). This definition has since become the seminal definition of Sustainable Development and is also taken up by the Council of the European Union in its Sustainable Development Strategy (EU SDS): "Sustainable development means that the needs of the present generation should be met without compromising the ability of future generations to meet their own needs" (European Council 2006). This notion emphasizes an inter-generational, or inter-temporal, view of Sustainable Development. Practical implementation can only partly incorporate that component, since inter-temporally comparable data with sufficient disaggregation and frequency is scarce. Complementing the inter-temporal perspective, the European Union's sustainable development strategy (EU SDS) breaks down the overall goal of sustainable development into key objectives:

- Environmental Protection,
- Social Equity and Cohesion, and
- Economic Prosperity.

The three key objectives correspond with the three dimensions, or themes, prevalent in the existing discourse on sustainable development, the environmental dimension, the social dimension, and the economic dimension. The indicator set laid out in this report is structured along these dimensions of sustainable development, breaking down the dimensions into policy categories, indicator target areas, and finally indicators.

Focusing on the Arctic Shipping Sector, this report is restricted to a relatively focused and confined scope, compared to existing studies and indicator sets on sustainable development in general. Typically, existing indicator sets take a global point of view, e.g. in terms of geographical scope, variety of economic sectors involved, variety of societal groups, variety of threats, or number of directly affected people. Indeed, a global perspective gives appropriate justice to the multiple regional, sectoral, or societal interactions that might easily be neglected by a more confined view on sustainable development. At the same time, a global approach risks to neglect important details of confined and special regions, economic activities, societal groups, or threats. We apply a more confined and yet more clearly defined approach that corresponds with the scope and focus of the ACCESS project and that favors a more in-depth consideration of Arctic peculiarities, and a more detailed description of the impact of Arctic Shipping.

3 The Arctic Ocean in an era of Change

The Arctic Ocean with its ice condition is in the process of change due to the development of the climate. Some years ago there was the Central Arctic covered year round with multiyear ice of 3m thickness and more which is a barrier even for strong icebreakers. Due to the Climate Change multiyear ice has drifted out of the Arctic and melted. The new ice freezing every winter season is only up to 2m thick, which is manageable by strong icebreaking ships.

There is a perception that Arctic Shipping is a fundamental technology for technical and economical activities. This includes the transit-shipping of commercial goods between Europe and East Asia, the supply (import / export) of the coastal areas around the Arctic Ocean and the transport of resources to the market in Europe and East Asia. All this requires a reliable and safe infrastructure with telecommunication, search and rescue systems and a reliable ice forecasting service, which improves the safety and economy of Arctic shipping. Several of these requirements for safe and efficient Arctic shipping are in certain areas of the Arctic Ocean already in action, but for a year round safe and economical transarctic and regional ship transport is still a lot to do.

Another issue for safe and economical shipping in and across the Arctic Ocean is the icebreaking technology. The Russian Atom- icebreakers are a big step forward, but there are as in many cases also here potentials for improvement such as reducing the broken ice floes in the channel behind the icebreaker, because they are dangerous obstacles for the ships in convoy.

4 Measuring and assessing sustainable development

4.1 The use of indicator systems for measuring the immeasurable

The role of indicators is to condense, estimate, or proxy information on a potentially abstract, not directly measurable entity in one variable, and that this variable will generate understanding about changes and direction of development. In our case, we attempt to measure sustainable development, as defined in Section 2. Flues et al. (2012) define indicators as parameters that theoretically or practically can be expressed in one number and that have a direct link to the aim of the indicator, in our case sustainable development. In order to compromise between conciseness and accurate coverage of the different dimensions of sustainable development, we introduce a set of indicators. Details on how we compose this set can be found in Section 04.2.

The need to measure sustainable development in the form of indicators was already identified in the early days of the modern sustainability debate. The Agenda 21, the seminal action plan adopted by the Rio Conference in 1992 states:

> *"Indicators of sustainable development need to be developed to provide solid bases for decision-making at all levels and to contribute to a self-regulating sustainability of integrated environment and development systems."* (United Nations 1992, § 40.4)

Accordingly, the aim of our indicator systems is to provide coherent information as decision support and monitoring tool for relevant decision makers (see e.g. Meadows 1998 or Bossel 1999 for an overview on aims of indicators on sustainable development). While diagnosis of the success or failure of decisions is a central role of the indicator system, we also regard diagnosis of the developments in the Arctic as a relevant aim per se. For example, researchers may want to use the indicator system defined in this report for the definition and development of model scenarios.

The indicator system aims to facilitate orientation in a complex multitude of social and ecological systems as well as their intersection. These systems may interact in various ways; they may be sensitive to exogenous determinants as well as random shocks. Their reaction to shocks, both from neighboring systems as well as from the outside may be non-linear. Their development may be self-enforcing or self-regulating. The indicator set may ideally also provide an early warning of drastic changes that allows for prompt control or counteraction. The role of the indicator system is to simplify this substantial complexity to a manageable amount. The price of such simplification is that some information is lost during the simplification process. In that sense, the indicator system is by construction an imperfect proxy for reality.

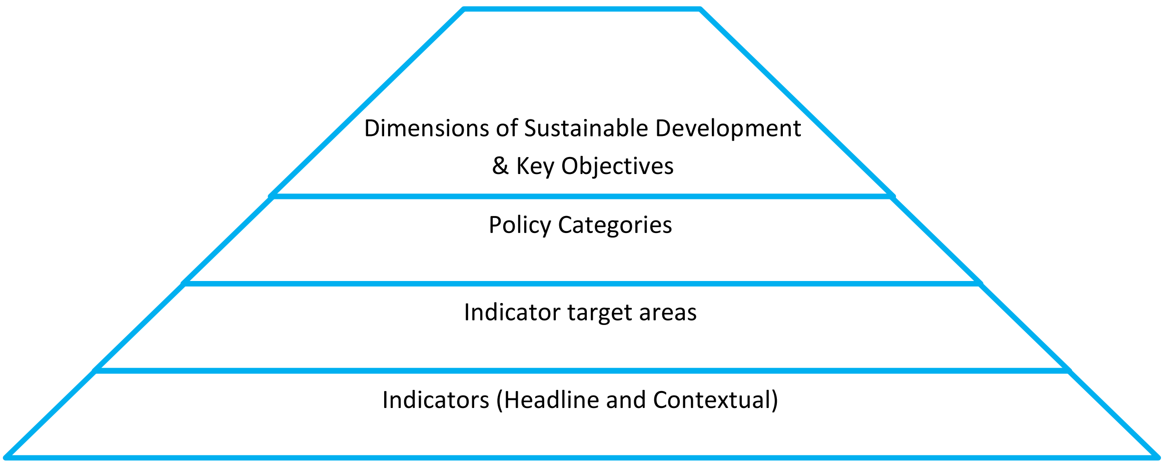
Even though there are some exceptions, many dimensions of sustainable development are meaningful only in a relative sense, also because there is rarely any general consensus about the optimal, sustainable state of the World and, in this specific case, about sustainable development in the Arctic. This means that we can only make statements that one observed state (e.g. in a specific region or point in time) is more or less sustainable than another state, provided that we have information on both states, and this statement may even vary for different stakeholders' points of view or even when we look at different dimensions of sustainable development. Thus, many indicators are meaningful only in comparison and not in absolute values, even though decision makers may want to define their own normative target corridors. For some indicators we will be able to provide guidance on what a sensible target or threshold value might be based on research or experts' heuristics.

Indicators describing sustainable development, on the one hand, and sustainable development and decisions impacting development on the other hand may refer to different stages of an underlying impact process. These different stages can be used to develop taxonomy of indicators such as the pressure-state-response taxonomy (cf. McCool and Stankey 2004 or United Nations 2007) and its various extensions. Pressure indicators reflect some kind of (positive or negative) pressure that human activity poses on ecosystems, social cohesion, or economic prosperity. They are often especially helpful as early-warning indicators. State indicators describe the state of ecosystems, social groups, or the economy. They often provide the most accurate description of, in our case, sustainable development. Response indicators reflect how decision makers, economic agents, etc. respond to changes in ecosystems, social cohesion, or economic prosperity. They are especially valuable for assessing the impact of policy measures. The pressure-state-response taxonomy has been extended to incorporate more dimensions of the underlying impact path. However, it will turn out that an adequate coverage of the pressure-state-response taxonomy is already difficult given the limited data availability for the Arctic.

4.2 Buildup strategy for the indicator system

Any indicator system must accommodate the conflicting interests of accessibility versus scope and detail. Some users would rather have a quick glance, requesting only very condensed and yet interpretable information. Other users, more deeply interested in specific dimensions of sustainable development, require multidimensional information reported by a multitude of variables. To accommodate these two needs, and following the European Union Sustainable Development Strategy, we structure our indicator set as a pyramid of indicators. The pyramid is made up of the three dimensions of sustainable development, derived from the dimensions' three key objectives, subdivided into policy categories, each specified by one or few indicator target areas, described by a number of indicators (cf. Figure 1).

Figure 1: Indicator Pyramid.



ACCESS illustration

By choosing this pyramid form, with the three dimensions of sustainable development as the starting point, and deducing actual indicators from there, we adopt a top-down approach that avoids defining sustainable development through the power of facts (i.e. available data) and overlooking areas where data is lacking. We complemented this top-down approach by a bottom-up approach that assessed data availability. The difference between these two reveals areas for future research.

The indicators themselves are provided by the heterogeneous experts assembled by the ACCESS project, covering a multitude of disciplines, nationalities and subjects of study. This ensures a high diversity of potential indicators and avoided narrowness. In a first step, by means of a breakout group session at the third ACCESS general assembly meeting in Villanova, Spain, ACCESS experts discussed different strategies for selecting indicators and identified a first draft of relevant indicators for Sustainable Development in the Arctic. In a second step a questionnaire was developed that relevant task leaders of ACCESS had to fill in ahead of a work package meeting dedicated to selecting relevant indicators. During this meeting, the pyramid concept in Figure 1 was introduced, each participant presented their responses to the questionnaire and raised issues related to the particular indicators proposed. Subsequently the universe of indicators provided by the experts was narrowed down and ranked within each dimension. During the whole process, selection and ranking of the indicators was guided by a set of classical quality criteria for indicator systems that are described in Section 4.3 Criteria for good indicators

Compiling a large list of different indicators is usually easy, but most users of an indicator system ask for a concise and limited concentration on the essential. Apart from good accessibility, a concise set of indicators has the advantage that one can focus limited resources on gathering good quality information for this particular set of indicators. The selection process should be based on quality criteria or requirements that define what makes an indicator better or worse than its counterparts.

Eurostat, in its report on the European Union Sustainable Development Strategy, distinguishes three quality criteria for indicators: policy relevance, efficient communication, and statistical quality (Eurostat 2011, p. 37). This general criteria catalogue is a common basis to many indicator systems, which is in line with an extensive discussion on quality criteria of sustainability indicators summarized by the “Bellagio Principles” (Hardi and Zdan 1997). Hass et al. (2002) summarize the quality criteria derived from the Bellagio Principles as policy relevance, simplicity, validity, availability of time-series data, good quality and affordable data, ability to aggregate information, sensitivity to small changes, and reliability. Further compilations of similar-in-spirit quality criteria catalogues include Coenen (2000) or work from the Organisation for Economic Co-operation and Development (e.g. OECD 2013; see Hass et al. 2002 for details).

We based our selection of indicators on how well they perform with regard to policy relevance, efficient communication, and statistical quality. Usually, however, and similar to other indicator sets, we have to compromise between these three classes of criteria, since no indicator meet all of criteria equally well.

5 Indicators on sustainable development in the Arctic Ocean

The result of the buildup process presented in Section 4.20is a compendium of indicators, organized along the environmental, social, and economic dimension (cf.

Table 1) and presented in Sections 5.1 to 5.3. It should, however, be noted that the boundaries between the different dimensions in terms of concrete indicators are not obvious in all cases. In each of these sections, we introduce the particular indicator target area and identify and describe indicators.

Table 1: Proposed indicators related to energy production and shipping in the Arctic within different policy areas.

Dimension	Key objective	Policy category	Indicator target area	Variable/ Indicator
Environmental dimension	Ecosystem viability	Pollution	Air pollution	Air pollution from ship engines and other poison inputs
			Noise pollution	Noise in the context of shipping
		Oil spill monitoring	Oil spill prevention and response	Oil spill protection
Social dimension	Social cohesion	Social Inclusion	Participation of indigenous Peoples	Indigenous Peoples in Arctic activities
Economic dimension	Sustainable economic development	Regional economic and infrastructure development	Size and nature of the Arctic shipping sector	Number of ships and mode of operations
			Infrastructure development	Infrastructure
			Safety	Ice Information
		Facilitating European Co-operation	Improvements regarding NSR shipping	Recommendations for improving the NSR shipping

ACCESS presentation.

We choose to focus almost exclusively on few indicators rather than a multitude of indicators because of the lack of information in the region. Time series data with appropriate geographical precision does, for example, not exist for a wide range of variables. Since data is unavailable for many of the indicators presented here, the indicator set can also serve as a first target for improved data collection.

5.1 Environmental dimension

The environmental dimension in this report focuses mainly on ecosystem viability and its capacity to produce ecosystem goods and services. The state of the ecosystem has a general relevance for the continued provision of ecosystems services including provisioning, supporting, regulating and cultural ecosystem services (MEA 2005).

We identified two relevant policy categories, pollution and oil spill monitoring. We measure pollution in the Arctic by air pollution from ship engines and other poison inputs (Section 0) and noise (5.1.2). In addition, we use oil spill protection as a relevant indicator for danger to ecosystems (5.1.3 0) Given the inter-linkages between the different dimensions of sustainable development, also some indicators form other dimensions inform about ecosystem viability, namely the number of ships and the mode of Operation

5.1.1 Air pollution from ship engines and other poison inputs

The increasing transit and regional transport along the Northern Sea Route and the North West Passage by ships using CO2 fuel is causing black soot pollution, which contributes to the melting of snow and ice. This air pollution by ships has been measured in full scale by an air craft campaign of flights behind 9 merchant ships northwest of Norway organized and analyzed by ACCESS WP2-Partners. (DLR, UPMC (LATMOS),University of Oslo).

An 18 MW powered icebreaking ship emits approx. 1 kg Black Carbon per hour or 200 kg for transiting the entire Northern Sea Route. Since most of these transarctic ships use the shipping in convoy guided by Russian Atom-icebreakers, the fuel consumption and associated emissions are reduced approximately by 50 % due to less power required in open water.

EU –Legislation and IMO are presently working on a law to accept ships over 5,000 gross tons in European harbors only driven by LNG - beginning in 2018.

This regulation will reduce the BC emissions of arctic ships departing from or arriving in Europe harbors.

Recent studies show that regulations on reducing Arctic shipping emissions alone are insufficient to reduce BC deposition in the Arctic Ocean, because a much higher amount of CO2 emissions is being produced on land south of the Arctic Ocean and transported by air from those regions to the Arctic Sea. There they cause a high melting rate of the Arctic ice with its negative effect on Climate Change. In order to get control on emissions from land-based sources these need to be considered together with regulations for activities in the Arctic. Actions should be taken by countries around the Arctic Ocean for reducing these air pollution sources.

5.1.2 Noise in the context of shipping

In the context of shipping, the main focus is on indicators of underwater noise, with some relation to impacts on the marine environment. Noise has been defined in many ways. For this report “noise” is taken to mean anthropogenic sound that has the potential to cause negative impacts on the marine environment (which in this case includes component biota but not necessarily the whole environment) and includes not only sound pressure levels, but also other features of sound.

Unfortunately, there is no systematic measurement program in the Arctic Ocean in place today that would generate comparable Arctic-wide data series of consistently good quality, not least because of the substantial cost associated with such a program.

However, the EU's Marine Strategy Framework Directive (MSFD) requires the Member States (MS) to develop strategies that should lead to programmes of measures that achieve or maintain Good Environmental Status (GES) in European Seas.

As an essential step reaching good environmental status, MS should establish monitoring programmes for assessment, enabling the state of the marine waters concerned to be evaluated on a regular basis. The MSFD comes with criteria and methodological standards on GES of marine waters (Commission Decision 2010/477/EU), including two indicators on noise (Descriptor 11, Noise/Energy): Low and mid frequency impulsive sounds as well as continuous low frequency sound (ambient noise). A consistent extension to Arctic non-member states to the MSFD could result in a coherent assessment of noise pollution in Arctic waters.

Ambient noise is defined as background noise without distinguishable sound sources. It includes natural (biological and physical processes) and anthropogenic sounds. Research has shown increases in ambient noise levels in some areas in the past 50 years mostly due to shipping activity. This increase might result in the masking of biological relevant signals (e.g. communication calls in marine mammals and fish) considerably reducing the range over which individuals are able to exchange information. It is also known that marine mammals alter their communication signals in noisy environments, which might have adverse consequences. This indicator is based on direct independent measurements.

Even though general methodological standards are defined, the MSFD Descriptor 11 leaves some room for protocol and results interpretation, and thus requires concretion on measurement and data processing. We therefore propose the following monitoring approach to address the indicator of noise from shipping:

- Identification of areas that should be monitored or modelled. Areas of interest are those that either habitat or are regularly visited by protected species (such as marine protected areas) and those that have increasing economic activities (such as harbours or zones marked for production of oil & gas). Areas suitable for modelling are those that have a homogeneous environment with a relatively simple bathymetry.

  Ideally all modelling would be validated with on-site measurements, but this is especially important for more complex areas, which would then need measurement equipment installed. Areas that are especially suitable for measurement are those that contain resident cetaceans.

5.1.3 Oil spill protection

Oil spills in Arctic Regions can and have occurred, when icebreakers or icebreaking cargo vessels are being refueled or loaded in Arctic harbors. Combating these oil spills is especially difficult, because the oil is floating between broken ice sheets, ice brash or ice slush. This problem has been investigated since many years and several combat techniques are available. One of the simplest technique within a harbor would be to surround the potentially oil spilling ship with a boom floating on the water. This technic could be modified to be appropriate also in open Arctic waters, when a tanker is loaded at an offshore production platform or in case of a ship accident.

5.2 Social dimension – Indigenous People in Arctic activities

The participation of Indigenous People is essential in the development of the Infrastructure for Arctic Shipping for example in the construction and operation of harbors like SABETA in the Ob-river on the Yamal Peninsula, in cargo management, search and rescue, communication and build-up of totally new regions for humans to live. Indigenous people were already involved in international Arctic Conferences for example in Salekhard (2013) and Tromso (2014) to mention only two.

As we know most of the CO2 emissions in the Arctic Sea Area is coming from continental regions south of the Northern Sea Route and is contributing to the melting of the ice on the Arctic Ocean and within to the Climate Change. With help of the regional and country governments the indigenous people could and should take part in reducing private and industrial emissions in their villages and regions.

In the framework of ACCESS a two-day Workshop in cooperation with a large number of Indigenous People took place in July 2014 in Paris. The topic of this workshop was to inform the Arctic natives on results of the ACCESS Project and to get their input for possible adjustments.

5.3 Economic dimension

The economic dimension focuses on a number of corresponding policy categories that nevertheless must not necessarily be directly related. We focus on regional economic and infrastructure development and European Cooperation. Our corresponding indicators are the number of ships and mode of operation (--5.3.1), infrastructure (5.3.2 0), ice information (0), and the level of fulfilment of recommendations for improving NSR shipping (0).

5.3.1 Number of ships using the Northern Sea Route and mode of operations

According to the NSR Administration in Moscow the cargo shipment in 2013 along the NSR amounted to 3930 thousand tons, this includes 1187 thousand tons of cargo mainly Ore, LNG and Gas-condensate transported by 40 vessels between Western Europe and East Asia.

Russia itself has been using the NSR in 2013 for importing and exporting 2743 thousand tones. In the same year the newly build LNG carrier ARCTIC AURORA with a capacity of 134 600 tons capacity started to transport LNG from Russia to Japan. Arctic Shipping via NSR and the adjacent regional Arctic areas amounted to 9 Million tons of cargo.

The majority of ships using the NSR are oil and gas condensate tankers with the required ice class. For safety and economic reasons the majority of these transarctic cargo vessels are using the shipping along the NSR in convoy, which is leaded by a Russian Atomic-Icebreaker. However the number of available Atomic Icebreakers is not sufficient for the number of cargo vessels; 71 vessels have used the convoy in 2013 at the NSR, 36 of them had to wait for the leading icebreaker at the point of convoy formation. This waiting time of the cargo vessels and the general increase of transarctic shipping have stipulated the Russian Government to order new atomic Icebreakers, the first one will be delivered in 2017.

5.3.2 Infrastructure

The infrastructure of Arctic Shipping Routes (NSR, NWP, NPR) need intensive adjustments to international shipping standards. This has been in detail addressed by AMSA (Arctic Marine Shipping Assessment). The most important shortages of the Arctic infrastructure are summarized in ACCESS Report D- 2.31 with the result, that the safety of shipping in the New Arctic is insufficient. It requires high investments in order to obtain international standards. Most important is as a consequence of this present situation that the ship operators are using the convoy for transarctic navigation by following a Russian Atom-icebreaker, which is experienced in transarctic shipping. Besides, the cargo vessels don't need to break the ice, which saves them time and approximately 50% of power.

The infrastructure in general along the Northern Sea Route is presently not well enough established. The telecommunication system along the coastline of Northern Russia needs a better coverage and density.

If the ice conditions in the Arctic Ocean continue to decrease, the Northern Sea Route should become for part of the year a Central Arctic Route close to the North Pole like it has been the case in 2012 with a small number of ship convoys. The entire infrastructure for shipping should be developed for this scenario. This means that the infrastructure parts Telecommunication, Search and Rescue, Ice Route Service and others need to be established for a certain time of the year close to the North Pole.

Since the use of LNG for ship powering will be a law in Europe starting 2018 - the EU Parliament is working on this law - the LNG ship power supply must be organized along the Russian coast of the Northern Sea Route and possibly also close to the North Pole Route at least by one seasonal stationed LNG tanker. This last option will depend on the further development of the Climate Change.

Ports are a key shipping infrastructure. The World Port Index provides details about ports throughout the world. It covers 3687 ports of which 159 are deemed to be in the Arctic. The data include a range of details about port characteristics, which rather than measured using a metric grouped into categories. For ports size is categorized into large, medium, small and very small based on a number of factors including area, facilities and wharf space. Maximum vessel size is categorized into just two categories, large for vessel in excess of 500 feet in length and medium for harbor that cannot accommodate vessels in excess of 500 feet.

The density of ports along the Arctic coasts in general is considerably lower than that along other coasts. In particular the east and north coast of Greenland, along the Russian coast, and the northern coastal regions of Canada.

A comparison of the size of ports in the Arctic with all ports (see Table 2) reveals that on average the ports in the Arctic are smaller, which of course is a function of the shipping activity taking place in the Arctic. In particular only 5.7% of ports in the Arctic are either large or medium in size compared to 14.1% for the all ports in the data.

Similarly, a smaller proportion of ports in the Arctic can handle vessels in excess of 500 feet long (17.2% in the Arctic compared to 36.9% across all ports). However, when it comes to facilities at the ports the differences between those located in the Arctic and all ports are quite small. For example fixed cranes are available in 93% of ports both in the Arctic and worldwide. Likewise medical facilities are available in 97% of ports both in the Arctic and worldwide, although there is no detail about the scope of the available medical facilities. However, given the fact that the distance between ports in the Arctic is greater implies that the density of facilities is lower in the Arctic, which is of relevance in case of an emergency.

Table 2: Size distribution and maximum vessel size of ports

Port Size	Arctic	World	Vessel Size	Arctic	World
Large	0,6 %	4,3 %	> 400 ft.	17,2 %	36,9 %
Medium	5,1 %	9,8 %	< 500 ft.	82,8 %	63,1 %
Small	19,3 %	26,9 %			
Very small	75,3 %	59,0 %			
Total	100 %	100 %	Total	100 %	100 %

Source: ESRI

5.3.3 Ice information

In order to use the Arctic Routes for shipping more efficient, better information about the ice conditions over a large area of the Arctic is needed. This can be achieved on the basis of satellite products and Route Assistance Tools (for example IRO2) in cooperation with weather-stations for information on the development of wind and ocean current conditions. As the IRO2 Test Voyage in 2014 in the Arctic Sea east of Svalbard has shown this technology can improve the economy and safety of Arctic Shipping and makes the Transarctic Shipping even more attractive.

5.3.4 Recommendations for improving the NSR shipping

The following recommendations have been selected for improving the safety and efficiency of commercial shipping in the Arctic Ocean especially between Europe and East Asia:

a) The economic attraction of the NSR shipping should be improved by engaging on return cargo by the shipping companies

b) The icebreaker fee must be adjusted to be competitive with the Suez Canal fee

c) The infrastructure for shipping along the NSR and the North Pole Route must be improved regarding telecommunication, search and rescue, ice route optimization including forecast of ice conditions and wind and ocean current direction and strength.

- d) A Deep Water Route along the NSR for safe navigation of large vessels with a depth of at least 16m should be defined and published in the relevant maps.
- e) Arrangement of LNG-service stations along the main Arctic- shipping routes: Northern Sea Route, North-West-Passage on the coast of Alaska and Greenland. These service stations should be equipped also with search and rescue equipment. In case the ice conditions allow using the North Pole Route a mobile service station close to the North Pole should be available for LNG supply and rescue service during the shipping season.
- f) Establishment of an EU-Center for information, administration, cooperation in using Transarctic Routes for cargo shipping between Europe and Northern Russia, East Asia and Canada. This Center should communicate with the Russian authorities on matters for improving the safety and economy in using the NSR.

6 A general caveat – uncertainties in the description of sustainable development

Apart from complex dynamics including nonlinearities, uncertainty is a major challenge for indicator systems. Given the vast changes the Arctic Ocean (as well as the oil and gas industry in general) is facing, it is impossible to cover changes in sustainable development in a comprehensive way. Uncertainty comes in various forms. To begin with, we simply do not know about all indications of changes in sustainable development, no matter how important some of them might be. In some cases, we might miss a whole dimension of sustainable development or its indication. In other cases, we might know about some cause-and-effect chains that affect sustainable development in the Arctic Ocean, but we may not know how, or in which direction, sustainable development is affected. In these cases, we do capture the relevant dimension of sustainable development, but we may fail in correctly interpreting changes in the indicators. These various types of uncertainty will affect the explanatory power of any indicator system. Furthermore, unexpected exogenous events, such as natural disasters, world market movements, or global economic crises will, although influencing sustainable development, impede the ability of the indicator set to reflect the success or failure of policy measures. For that reason, indicators will usually be merely descriptive of potential outcomes of decisions, without necessarily implying an underlying causality. Assessing causality between changes in different indicators requires the use of additional explanatory tools like models. In spite of this, the choice of a relevant set of indicators should still be driven by an underlying understanding of dimensions that would potentially affect the direction of sustainable development.

7 Conclusions

The reduced ice conditions in the Arctic Ocean as a consequence of Climate Change has increased the Cargo Shipping between Europe and East Asia along the Northern Sea Route. A further development and usage of the Arctic Route requires the improvement of the infrastructure with telecommunication, search and rescue, and LNG service stations along the route.

The number of powerful Atom- icebreakers must increase for the convoy guide of cargo ships as has been positively practiced in last years. The formation of convoys requires improvement in communication between the cargo ships and also with the convoy leading icebreaker.

The following indicators have been selected as parts of the sustainable development in Arctic Ocean Shipping:

- Environmental Dimension
  - air pollution from ships
  - noise in the context of shipping
  - oil spill protection

- Social Dimension, including the Indigenous People in the development of shipping related activities in their home area

- Economic Dimensions
  - Increasing number of ships and mode of operations
  - Improvements of Infrastructure
  - Ice information
  - Recommendations for improving the NSR shipping

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