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ACCESS

Arctic Climate Change, Economy and Society

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D5.31 - Assessment of inputs regarding climate change effects and impacts on extant regulatory systems and overview and review of predicted stress on these systems

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Preamble

This document provides a summary of three inter-related topics relevant to the project "Arctic Climate Change, Economy and Society" (ACCESS). These topics address issues within the Work Package 5 - "Governance, Sustainable Development and Synthesis". These three areas form the current report, deliverable D5.31, and comprise an analysis of:

1. **Long term climate change in the Arctic Ocean;**
2. **Impacts on existing regulation systems;**
3. **Predicted stress on regulation systems.**

The first of these tasks we address by synthesising materials culled from the IPCC 2007 Assessment Report, and supplied by, and suplemented by ACCESS Work Package 1 (Climate Change and the Arctic Environment) analyses. These summarise the expected effects of climate change in the Arctic over the long-term (30 year) period addressed by the project. The main questions we address are presented in Box 1:

Box 1

- *What are the main physical changes to be expected in Arctic ice cover and type over the next 30 years?*
- *What are the meteorological changes likely to occur during the same period and where are these effects going to be felt most prominently?*
- *What other environmental changes will likely be relevant during the next 30 years of climate change?*

The second of these tasks we address by considering effects of a simulated re-location to the Arctic Ocean of recent, well-documented major maritime events occurring elsewhere in the world, and evaluate the potential impact on each or several of the three sector operations under study by the ACCESS programme: shipping and maritime transportation, fisheries and oil and gas exploitation. We use these scenarios to simulate the potential effects on the Arctic environment, allowing us to focus on the challenges to existing sectoral, or general, regulatory systems. Our challenges are outlined in Box 2:

Box 2

- *What similarities and what differences could be identified between the setting in the original event and the "Arctic-based" simulated one?*
- *What regulations would be affected by such an event(s) taking place in the Arctic?*

The third task will be accomplished by examining the lessons learnt from the recent events used in the simulations above, reviewing how these can be used to identify potential stress on existing regulatory systems and so point up the challenges to the development of good governance. We summarise these aims and objectives in Box 3:

Box 3

- *What legislative/regulatory additions and amendments are going to be needed to deal with changing physical conditions in the Arctic Ocean over the next 30 years of climate change?*
- *At which level should these modifications be developed - multilaterally, internationally, nationally or regionally?*
- *What measures can be in place to ensure that regulations will be adaptable to the continually changing conditions and context of activities in the Arctic Ocean?*

Ultimately, the purpose of the document is to deliver an understanding of how the various regulatory systems presently in place, internationally, regionally and nationally, will be challenged by climate change - and this in turn will inform the project as to how strategic planning can be developed to address these challenges before they become unmanageable. This document records our findings and predictions at the half-way point in the ACCESS project[1], and as planned, we will update our review throughout the remaining work and present final results in a concluding set of governance related reports at the end of the ACCESS programme (see Deliverables 5.41 and 5.91, among others)[2]

[1]The ACCESS project commenced on 1st March 2010, and is scheduled to be completed by 28th February 2014. See http://www.access-eu.org/

[2] D5.41 - The production and summary of governance options over the ACCESS time period (ca. 30 years); D5.91 - Report on cross-sectoral synthesis of economic, policy and governance options for sustainable development

1 Climate change in the Arctic Ocean

We summarise the expected changes in the physical environment of the Arctic Ocean to include the following: lateral ice-reduction; sea-ice volume and thickness reduction; increase ice mobility; seawater temperature rise; and extreme weather focusing. We discuss each of these parameters in turn and include, where possible, predictions of climate change effects up to and beyond the 30 year ACCESSS period of study.

We recognise that much of this narrative is derived from analyses of the Intergovernmental Panel on Climate Change (IPCC) which are in many cases at least 5 years old. The details are undoubtedly likely to need revision (and ACCESS will address this issue in due course) but these first order effects of climate change will be assumed to be understood. We note that updates on these findings and predictions are to be available from IPCC Working Groups following their synthesis scheduled for 2013/2014.

1.1 Lateral sea ice reduction:

There will be an annual mean decline in Arctic sea ice extent of 2.7 ± 0.6 % per decade (IPCC, 2007). This reduction is not temporally uniform, as the decline for summer extent is larger than for winter. These trends have to be superimposed, nevertheless, on substantial inter-annual to decadal variability which is associated with variability in atmospheric circulation (Polyakov et al., 2003).

Overland and Wang, 2007 conclude that: “Based on the selection of a subset of models that closely simulate observed regional ice concentrations for 1979-1999, we find considerable evidence for a predicted loss of sea ice area of greater than 40% by 2050 in summer for the marginal seas of the Arctic basin. This conclusion is supported by consistency in the selection of the same models across different regions, and the importance of thinning ice and increased open water at mid-century to the rate of ice loss. With less confidence, we find that the Bering, Okhotsk and Barents Seas have a similar 40% loss of sea ice area by 2050 in winter. Baffin Bay/Labrador shows little change compared to current conditions. These seasonal ice zones have large inter-annual/decadal variability in addition to trends. Large model to model differences were seen for the Kara/Laptev Seas and East Greenland.“ These observations have been recently updated from IPCC AR5 draft material within WP1 of ACCESS[3]

1.2 Sea ice volume thickness reduction:

Models show a range of responses in northern hemisphere sea ice areal extent

[3] Especially see internal communication of ACCESS (2012)- "Sea-ice in Climate Scenarios", by Kathrin Riemann-Campe (Alfred-Wegener-Institut für Polar- und Meeresforschung Bremerhaven) Kathrin.Riemann-Campe@awi.de

ranging from very little change to a strong and accelerating reduction over the 21st century. Nonetheless, researchers conclude that the models show reductions in summer (September) and winter (March) over the next 30 years. An important characteristic of the projected change is for summer ice area to decline far more rapidly than winter ice area (Gordon and O'Farrell, 1997), and hence sea ice rapidly approaches a seasonal ice cover. Seasonal ice cover is, however, rather robust and persists to some extent throughout the 21st century in most (if not all) models. Consistent with these results, a projection by Gregory et al. (2002) shows that Arctic sea ice volume decreases more quickly than sea ice area (because trends in winter ice area are low) in the 21st century.

1.3 Increase in sea ice mobility:

Sea ice mobility is a natural consequence where the drift of sea ice is primarily forced by the winds and ocean currents. Proshutinsky and Johnson (1997) and subsequent analyses show the existence of two regimes of Arctic ice/ocean motion driven by large-scale variations in atmospheric circulation, including large scale shifts of the orientation of the transpolar drift. Rigor at al. (2002) showed that the changes in the patterns of sea ice motion from the 1980s to the 1990s are also related to the non-systematic pattern of non-seasonal sea-level pressure variations, referred to as the Northern Annular Mode (NAM). There is, however, no clear indication of a long-term trend in ice motion yet. the IPCC suggest that a systematic analysis of future projections for the Arctic Ocean circulation is still lacking. WP1 continues to synthesise existing studies and new results from ACCESS with specific emphasis on resolution of sea-ice mobility[4].

1.4 Sea-water temperature rise:

Average Arctic temperatures have increased at almost twice the global average rate in the past 100 years. Arctic temperatures, however, have high decadal variability. The IPCC comments on the expected change: “The Arctic is very likely to warm during this century in most areas, and the annual mean warming is very likely to exceed the global mean warming. Warming is projected to be largest in winter and smallest in summer (2007)".

1.5 Extreme weather focusing:

Regional studies all show patterns of changes in extremes consistent with a general warming, although the observed changes of the tails of the temperature distributions are often more complicated than a simple shift of the entire distribution would suggest. In addition, uneven trends are observed for night-time and daytime temperature extremes. Studies of rapid pressure changes at stations indicate an

[4] ibid, see 3

increase in the frequency, duration and intensity of winter cyclone activity over the lower Canadian Arctic since the 1950s, but a decrease over southern Canada and Iceland (Wang et al., 2006b; Alexander et al., 2005). Besides a northward shift of the storm track, the station pressure data for parts of the North Atlantic region show a modest increase in severe storms in recent decades. IPCC says “Very little work has been done in analysing future changes in extreme events in the Arctic. However, simulations indicate that the increase in mean temperature and precipitation will be combined with an increase in the frequency of very warm and wet winters and summers".

Overall we have to acknowledge a large degree of uncertainty with climate predictions for the next 3 decades. This is due to the large natural variability, especially at high latitudes, in conjunction with model uncertainties[5]. These issues have been thoroughly discussed at the ACCESS WP1 workshop on Climate Scenarios in Bremen, September 2011, and summarised in subsequent reporting[6].

As a consequence, the study of climate change effects and impacts which focusses on the Arctic on the timescale for the next 3 decades inevitably needs to take into account a range of possible developments, rather than a clear prospect of how the climate system will evolve during this period. This means in turns that we will have to analyse the impacts and stress on the regulatory systems from the perspective of the sensitivity of the system to a range of climatic developments.

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[5] See, for example Hawkins, Ed, Rowan Sutton, 2009: The Potential to Narrow Uncertainty in Regional Climate Predictions. *Bull. Amer. Meteor. Soc.*, **90**, 1095–1107.

doi: http://dx.doi.org/10.1175/2009BAMS2607.1)

[6] ibid, see 3

2 Impacts on existing regulations

In this section we turn to the assessment of the impact of the effects of long-term climate change upon the existing regulatory regime/regimes. To achieve this we will simulate two major marine events in the Arctic Ocean - one a major oil extraction platform failure, the other a shipping accident. We will use documented analyses of recent events of this type which have occurred elsewhere in the world, in particular to assess how successful the implementation of relevant regulatory systems has been (in the 'real' examples) and might be (in our Arctic 'simulations'). Finally we will examine these findings in the context of our analysis of environmental change in the Arctic (as discussed in Section 1, above) to predict how successfully extant regulations would operate under these conditions.

2.1 Existing regulations

ACCESS report D5.11 (2011)[7] provides a summary framework of regulations against which to measure impacts of climate change. The principal objective of deliverable D5.11 was to provide an overview of regulatory systems, legislation and agreements relevant to the three key sectors of activity in the Arctic Ocean of interest to the ACCESS project; maritime shipping/tourism, fisheries, and resource extraction. It lists current regulations with a view to assessing their effectiveness, shortfalls, and conflicts - and to identify any legislatory gaps. The compilation delivers a basis with which to assess the strengths and weaknesses of these systems as they might respond to climate change over a significant time (for the ACCESS project we consider a period of 30 years).

This current report (D5.31) takes these legislative systems, and examines the stress placed upon them over time by the predicted climate change effects. It seeks to do this by envisaging a simulated major event, or events, for the region which test separately or collectively the effectiveness of regulations of different sectoral activities affected by each event. These events do not in themselves provide answers to the questions we tasked ourselves with (Box 2). They do, however, at the first level, highlight the areas of legislation on which we need to focus our attention. We examine these further in our discussion of effects of climate change on the effectiveness of the regulatory system in the final section of this report.

With respect to the oil and gas exploitation sector, we consider the consequences of a similar event to the BP Deepwater Horizon blow-out in April 2010 and the subsequent oil spill and pollution as if it had occurred in the Arctic Ocean. This event in the Gulf of Mexico caused almost unprecedented amounts of damage to the environment and the industry, and the numerous reports and voluminous analytical documentation published provide us with a rich source of information on

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[7] "Analysis and synthesis of extant and developing regulatory frameworks" - Report D5.11, 2011. (ACCESS EU Collaborative project No. 265863)

management (and mis-management) of such an event. We use this information to assess what could happen in the Arctic and what the impacts on the prevailing body of relevant regulations would be.

For our study sector of shipping, tourism and maritime transportation, we consider the consequences of an event in the Arctic Ocean equivalent to the cruise ship MS Costa Concordia running aground on the western coast of Italy on the 13th January, 2012. At least thirty people lost their lives in the event. After the event, the re-float and salvage programme, more than a year on, is stalled due to mounting uncertainty as to how to deal with the unstable wreck. At the time of this report, there remains a real danger of further disintegration and damage to the environment, including release of considerable amounts of heavy fuel which still remain trapped in unreachable parts of the vessel.

For either of these events, it is not necessary to locate the event precisely in any part of the Arctic Ocean, as the results we are to imagine from such events are intended to be generic. The purpose of the exercise is to observe, examine and understand what regulations were in place, were implemented, and how.

2.2 An oil event simulation in the Arctic

Our simulation for an oil event in the Arctic Ocean imagines that an equivalent of the Deepwater Horizon (DWH) tragedy could occur at a polar offshore installation as it did in the Gulf of Mexico in 2010. The events surrounding the disaster are well-known, so we will need only to summarise briefly for the purposes of context.

On the 20th April of that year, an explosion occurred on the Deepwater Horizon rig as it was in the final stages of drilling the exploratory Macondo well in 1522 metres of water in the northern Gulf of Mexico. Following the failure, for the next three months, oil flowed from a broken wellhead assembly at the seafloor, resulting in the largest accidental marine oil spill in the history of the petroleum industry[8].

As well as 11 oil workers tragically losing their lives in the incident, 17 others were injured. In total, 4.9 million barrels of oil were discharged over 85 days (the equivalent of 2.5 million gallons each day). In the clean-up campaign, 1.8 million gallons of dispersants were used. There were nearly 50,000 personnel involved in the clean up, operating on 9700 vessels and 127 surveillance aircraft. The operation involved 1.16 million metres of hard boom and 2.96 million meters of soft boom as containment devices.

It is impossible to imagine that such a supply of infrastructure and or personnel would be available in the Arctic at any time in the short- or even in the long-term future.

The conclusions made by the US President-appointed National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling were clear, sobering and damning, including stating that among other things, "*regulatory control and management was woefully inadequate*", or where it was in place, "*was not implemented correctly or as intended*" - (emphasis added)

In particular, in respect of future activities of this kind, it was recognised that it would be necessary:

> • To assure human safety and environmental protection, *regulatory oversight of leasing, energy exploration, and production require reforms* even beyond those significant reforms already initiated since the *Deepwater Horizon* disaster. *Fundamental reform will be needed in both the structure of those in charge of regulatory oversight and their internal decision* making process to ensure their political autonomy, technical

[8] "Deep Water - The Gulf Oil Disaster and the future of Offshore Drilling". Report to the President by the National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling, January 2011, 398pp.

expertise, and their full consideration of environmental protection concerns. (Emphasis added)

• Because *regulatory oversight alone will not be sufficient to ensure adequate safety,* the oil and gas industry will need to take its own, unilateral steps to increase dramatically safety throughout the industry, including self-policing mechanisms that supplement governmental enforcement.

• *The technology, laws and regulations, and practices for containing, responding to, and cleaning up spills lag behind the real risks associated with deepwater drilling* into large, high-pressure reservoirs of oil and gas located far offshore and thousands of feet below the ocean’s surface. Government must close the existing gap and industry must support rather than resist that effort.

• (And most chilling, and specific to the ACCESS programme's goals) the report states that *"[s]cientific understanding of environmental conditions in sensitive environments in deep Gulf waters, along the region’s coastal habitats, and in areas proposed for more drilling, such as the Arctic, is inadequate. The same is true of the human and natural impacts of oil spills*".

While we recognise that these comments are made specifically in relation t the DWH event, and that other Arctic states, (Norway, for example) follow exemplary regulatory procedures, these four bullets above - with emphasised sections added by the authors of this report - epitomise the difficulties in providing management and regulation for all eventualities, and, that despite extensive national and international regulations which were in place and of direct relevance to the exploration on the US continental shelf in the Gulf of Mexico[9] the regulatory system failed on many levels. The NAE/NRC Report summarised this as follows: "*The regulatory regime was ineffective in addressing the risks of the Macondo well. The actions of the regulators did not display an awareness of the risks or the very narrow margins of safety*.[10]"

More specific studies on the potential effects of a major oil event on the Arctic are given by (among others): 1 - 'Staff Working Paper (No. 5) of the National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling' released

[9] Among them, being the Outer Continental Shelf Act of 1953 and Amendments of 1978; the Magnusson-Stevens Fisheries Conservation Act; the Endangered Species Act; the National Environmental Protection Act; the Marine Mammal Protection Act; the National Marine Sanctuaries Act; the Clean Water Act; and the Oil Pollution Act of 1990 - see D5.11 for some details and links

[10] Macondo Well - Deepwater Horizon Blowout - Lessons learnt for improving Offshore Drilling Safety. National Academy of Sciences. May 2012. http://www.nap.edu/catalog.php?record_id=13273

into the public domain originally on 6 October 2010 and updated 11 January 2011 (http://www.oilspillcommission.gov/resources#staff-working-papers 0 and; 2 - "Oil Spill Prevention and Response in the U.S. Arctic Ocean: Unexamined Risks, Unacceptable Consequences", 2010 Commissioned Report by the US Arctic Program Pew Environment Group (see http://www.pewenvironment.org/news-room/reports/oil-spill-prevention-and-response-in-the-us-arctic-ocean-unexamined-risks-unacceptable-consequences-8589942645).

Lessons have to be learned from any accident/challenge to any system, but in drawing lessons from prior accidents, it is essential that they be projected beyond the particular circumstances of the accident under scrutiny, to guide present and future performance. For example, it has been recognised that despite the steps taken in the aftermath of the Exxon Valdez disaster to enhance transportation safety and oil spill response from a tanker spill, too little effort was made to take those lessons and apply them more broadly to the risks associated with the future of offshore drilling, with respect to the 2010 events in the Gulf of Mexico. it is even more unlikely that these steps are applicable to or have been implemented for, current and future exploration in the Arctic environment.

It would be therefore important to ensure, as far as possible, that as few as possible of the same mistake(s) made at one extreme event should be repeated at future events. Our scenarios for the oil and shipping disasters in the Arctic will seek to illustrate this.

2.2.1 The challenges of the Arctic for oil and gas industry

The Arctic is well in the sights of the oil and gas industry. US outer continental shelf areas from US alone are predicted to peak at 1.8 million barrels a day in the next decade. Russia, Norway, Canada, and Denmark (Greenland) are also in the process of evaluating, or already are, exploiting their Arctic oil and gas resources. The oil industry, however, is complex and in many ways somewhat fragmented. It has its own internal regulations, but needs at the same time to comply with international standards in situations which are complex and with ever-changing conditions. In the Arctic, more than anywhere, the industry needs to identify those operations that present the greatest risks because of the type of exploration and production drilling (for example, deepwater or ultra-deepwater), the challenges of drilling in a particular kind of or less-well-known geologic formation, and a location of the operation in a remote frontier area where containment and response resources may be fewer, and affected by additional factors, such as severe climate change effects, or ice issues. It is obvious that all of these high-risk factors apply individually and collectively to hydrocarbon exploration and exploitation in the Arctic region.

In exercising and maintaining regulations for the industry, it will be necessary to ensure correct and rigorous implementation of these regulations by all responsible parties. Application of the regulations at levels appropriate to extreme conditions prevalent in frontier areas such as the Arctic Ocean are essential and must be strictly enforced and the process of enforcement itself monitored.

Finally, it is critical that whatever systems are in place, they will need to be structured to ensure a long-term ability to innovate and adapt over time to changing challenges, new frontiers and technologies.

In addition to presenting important differences for implementing any drilling program—different geological context, hydrocarbon formations, coastal communities, environments and climate conditions, to mention a few, - the Arctic is characterized by extreme cold, drifting and pack ice, extended seasons of darkness, hurricane-strength storms, and pervasive fog—all affecting access and working conditions. As we have seen in the introductory section, these physical conditions are increasingly set to change in intensity and effect on the industry steadily over the next thirty years, and more.

The geological pressures in hydrocarbon deposits in Arctic sites with high oil and gas prospectivity may well be substantially below those encountered at the deeper waters at the Gulf of Mexico disaster site (due to thinner sediment overburden and shallower water depths) and so this in turn may mean some reduced risk of a major blowout. But oil spilled in polar waters (from blowouts, pipeline or tanker leaks, or other accidents) is likely to degrade more slowly than that found in the Gulf of Mexico because of lower temperatures, reduced mixing of oil with water due to the presence of ice, and the shallower depths through which oil would travel from the wellhead to the surface. It is reasoned that the slow weathering could facilitate the skimming and in situ burning of escaped oil under ideal weather conditions, but the slow pace of natural dispersion means that oil would linger much longer in the marine environment. Furthermore, serious questions remain about how to access spilled oil when the area is iced over or in seasonal slushy conditions.

The stakes for drilling in the Arctic are raised by the richness of its ecosystems. The marine mammals in marginal sea regions are among the most diverse in the world, including seals, cetaceans, walruses, and bears. The Arctic Ocean also supports millions of shorebirds, seabirds, and waterfowl, as well as abundant fish populations.

It is known that these are vibrant living systems, but scientific research on the ecosystems of the Arctic - let alone on the impact of oil spillage - is difficult and expensive. ACCESS has already produced its first report on capabilities and technologies[11] regarding oil spills, and a number of others are planned[12].

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[11] "Oil spill response capabilities and technologies in ice-free and ice-covered water" - 2012 - Report D4.41, 2011. (ACCESS EU Collaborative project No. 265863)

[12] See ACCESS EU Collaborative project No. 265863, work plan Work Package 4.

The existing gaps in data also support an approach that highlights in leasing decisions those areas where information exists and those where it does not, as well as where response capability may be less and the related environmental risks may therefore be greater. It could be argued that the need for additional research should not be used as a de facto moratorium on activity in the Arctic, but instead should be carried out with specific timeframes in mind in order to inform the decision-making process. On the other hand, recent interested government investigations (such as the UK Parliamentary Study)[13] suggest that there is a real fear that the industry is moving in advance of satisfactory legislation and, in particular, environmental control.

As has been mentioned on the final report on the DWH disaster[14], in terms of dealing with oil spill response and containment, the remoteness and weather of the Arctic frontier create special challenges in the event of an oil spill. Successful oil-spill response methods from the Gulf of Mexico, or anywhere else, cannot simply be transferred to the Arctic.

Industry and academic organizations are conducting research on response to oil on and under ice, but more needs to be done. The DWH report suggests that a comprehensive interagency research programme to address oil-spill containment and response issues in the Arctic should be developed, funded, and implemented. Furthermore, that an Arctic Regional Citizens Council could help assure the active participation of the people who know this region the best in planning and response. Spill trajectory and weather models based on Arctic conditions must also be developed. While these recommendations are extracted from the DWH US report, it is self-evident that they should be considered as generic and a base for standardisation/review in the region.

The Arctic is shared by multiple countries, many of which are considering or conducting oil and gas exploration and development. The extreme weather conditions and infrastructure difficulties affect all Arctic countries. The damages caused by an oil spill in one part of the Arctic may not be limited to the waters of the country where it occurred. Strong international standards related to Arctic oil and gas activities should be considered among all the countries of the Arctic. Such standards would require cooperation of states, stakeholders and the close coordination of policies and resources. The Arctic Council has begun work in this direction, updating its voluntary Arctic Offshore Oil and Gas Operation Guidelines in 2009, and developing an oil spill response agreement, due to be adopted in May 2013.

Bringing the potentially large oil resources of the Arctic outer continental shelf into

[13] http://www.publications.parliament.uk/pa/cm201213/cmselect/cmenvaud/171/171.pdf

[14] ibid - "Deep Water - The Gulf Oil Disaster and the future of Offshore Drilling". Report to the President by the National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling, January 2011, 398pp.

production safely will require an especially delicate balancing of economic, human, environmental, and technological factors. Both industry and governments will have to demonstrate standards and a level of performance higher than they have ever achieved before. One lesson from the Deepwater Horizon crisis is the compelling economic, environmental, and indeed human rationale for understanding and addressing the prospective risks comprehensively, as well as establishing and implementing appropriate working regulations before proceeding to drill in such challenging waters.

We have attempted to integrate the predicted results of long term climate change in the Arctic with how they are likely to affect some of the key impacts envisaged for a major oil industry event, using a summary table, below (Table 1). Our principal effects of long term climate change are summarised in Box 4,

Box 4 - Long term climate change effects:

- less summer ice coverage;
- greater ice mobility;
- thinner ice cover;
- extreme weather patterns - increased and localised cyclonic activity;
- warmer waters.

and are projected onto recorded effects from the simulated oil event in the Arctic, as summarised in Box 5 - the results are summarised in Table 1.

Box 5 - Oil sector disaster simulation factors (derived from Deepwater Horizon event)

- Oil spill surface distribution;
- Oil landfall and contamination;
- Disruption to surface fisheries industries;
- Damage to marine and wildlife habitats;
- Seabed contamination;
- Damage to fishing industry;
- Damage to tourism;
- 'Kill zone' around the well;
- Length of contaminated shoreline.

In Table 1, the matrix of expected results and effects has been colour-coded (traffic light-fashion) to identify the most serious of the threats to the regulation system. Red highlight indicates how the predicted climate change parameter (labelled in pink) would be expected to strongly amplify the impact of the particular consequence of the event (labelled in blue in the table). Orange, through yellow to green highlighting reflects decreasing levels of this effect. Where an effect is negligible or non-existent, no shading is used.

Compare this with the results of table 2 for the Tourism/transportation event effects.

Table 1 - Preliminary review of how the predicted results of long-term climate change in the Arctic are likely to affect (enhance, augment, modify) key impact parameters of a major oil spill event. At this stage we have not factored in temporal variability of the effect (i.e., views on whether the effect is transitory, long-lasing, or permanent). This study will form part of our future/subsequent reporting.

	Less ice cover	**Greater ice mobility (more icebergs)**	**Thinner ice cover**	**Focused extreme weather**	**Sea temperature rise**
Oil surface spill	Spills can travel greater distances: DWH-type event results in more widespread dispersal of oil slick and contaminants	Greater difficulty in dealing with spill products?	Sub-ice spill more likely to reach surface. Sub-ice spill accumulation beneath ice may be less of an issue as it may escape through breaches in ice-cover.	Cyclonic weather systems will affect marginal/coastal seas, so will be most severely affected. Both natural redistribution and dispersal are increased. Spills may travel greater distances via enhanced surface current activity.	Change will not be at a rate to make any difference to evaporation/dispersal
Oil landfall and contamination	Wider distribution of contaminants along shoreline	No specific significant effect?	No specific significant effect?	Enhanced difficulty in dealing with/clearing spillages	No specific significant effect?
Oil damage to surface fisheries	More persistent damage due to greater distribution of oil	More hazardous clearance procedures	No specific significant effect?	More hazardous clearance procedures	No specific significant effect?

Damage to marine and wildlife habitats	More widespread damage due to greater dispersal time. Greater access of contaminants to habitats and protected areas	No significant effect on coastal communities, but mobility is clear threat to open ice habitat	No specific significant effect?	Possible wider dispersal of contaminants and more widespread damage	No specific significant effect?
Seabed contamination	No specific significant effect?	No specific significant effect?	No specific significant effect?	No effect?	No specific significant effect?
Disruption of fishing industry	Wider spread of spill to affect fisheries/ sites	Ice mobility may restrict access to alternative sites	No specific significant effect?	No specific significant effect?	Temperature rise effects on fishing may make habitat more vulnerable and more susceptible to spill effects
Disruption of tourism industry	More dispersed oil spill. Distribution of unsightly spill and clear-up activities				No specific significant effect?
"Kill zone" around well	No effect?	No effect?	No effect?	Likely wider area of damage due to current and weather movement of spill products	No effect?
length of contaminated shoreline	as spills travel farther and are less quickly dissolved, greater shoreline length will be contaminated and probably for longer - as the clear up will be operationally challenging		No effect?	More distributed spill products	No specific significant effect?
Long term release of oil from seabed over time	Visible over wider area	No specific significant effect?	No specific significant effect?	Monitoring of release less easy to monitor.	Not known

2.3 A marine shipping event simulation in the Arctic

This section of the report considers the geo political and socio economic implications of the steadily growing Arctic cruise tourism business. A business that within the timescales considered in this study is likely to have quasi-unfettered geographical access to the waters of the Arctic area due to the forecast disappearance of the ice cap. To aid in bringing these considerations into sharp focus we envisage a shipping scenario that sees a Costa Concordia type disaster occurring in these waters.

2.3.1 The Costa Concordia Disaster

The MV Costa Concordia, a 114,147 ton Italian tourist ship owned by Costa Crociere and the Carnival Corporation was on a seven day cruise during January 2012 in the Western Mediterranean, carrying 3229 passengers and 1023 crew, when it struck a granite reef located in waters 900 feet from the coast of the Italian Island of Giglio near the entrance to its port. The cruise was a mixture of visits to traditional Mediterranean ports combined with passage near to iconic coastline and islands.

The collision caused a 164 feet gash in the port side of the vessel below the waterline. The vessel flooded and listed to port eventually coming to rest on its starboard side in 45 feet of water. The evacuation of the vessel was delayed by an hour and when it was finally called the abandonment was described as chaotic. This saw a number of passengers and crew jumping into the sea and swimming away from the vessel with other passengers having to evacuate the vessel from the side nearest the sea. The final outcome of the evacuation saw 21 fatal casualties with 11 people still missing. If the accident had happened further offshore, or in colder waters or adverse weather conditions, the death toll would likely have been much higher.

The vessel had been recently fuelled and was carrying approximately 2,300 tons of fuel in 17 double skinned tanks. No fuel was lost at the time of the disaster, and all accessible fuel was subsequently removed as part of the salvage operation which began in February 2012, and continues to the present day. The area in which the disaster took place is designated as a national marine park [Santuario dei Cetacei] which is the biggest of its type in Europe focusing on the protection of marine mammals.

This event is used only an example of the possible scenarios occurring in the Arctic, as levels of tourism-driven marine transportation activity increases. We firstly briefly summarise the changes which are documented for the shipping, tourism and transportation industries.

2.3.2 Arctic Shipping Routes

In their paper published in the 2012 in the Arctic Yearbook Humpert and Raspotnik (2012) relate the four types of shipping activity first described in the AMSA Report (2009). These activities being:

- Destinational transport;
- Intra-Arctic transport;
- Trans-Arctic transport; and
- Cabotage (transportation by vessel of good and people between two points within the same country).

Furthermore, four main shipping routes already exist in 2012 or are likely to exist within the time span under study by this project report (Figure 1). These routes are the:

- Northwest Passage (NWP);
- Northern Sea Route (NSR);
- Transpolar Sea Route (TSR); and the
- Arctic Bridge (AB).

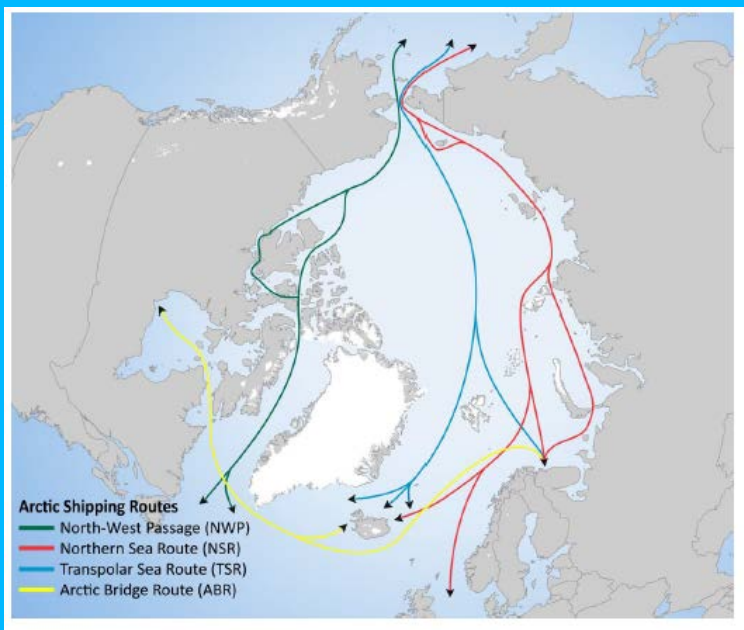

Figure 1 - The Major Arctic Shipping Routes (Source: Arctic Yearbook 2012 Humpert and Raspotnik [2012])

One of the findings of the 2009 Arctic Council '*Arctic Marine Shipping Assessment Report'* (2009) noted that:

> *" .... Most shipping in the Arctic today is destinational, moving goods into the Arctic for community resupply or moving natural resources out of the Arctic to world markets. Nearly all marine tourist voyages are destinational..."*

The forecast opening of the Arctic 'northern routes' considered in this report to a greater range commercial shipping will see this trade being designated as transnational.

However, an ice free Arctic has seen and will continue to see an increase in marine tourist voyages but these will remain primarily destinational and intra Arctic in nature utilising the increased access to iconic polar vistas and wildlife provided by the ice free waters.

2.3.3 The Arctic Cruise Tourism Business

In their paper Stewart and Draper (2008) provide a good overview of the development of the polar [Antarctic and Arctic] cruise tourism up to 2008.

A telling example is that the first cruise on the *MV Explorer,* a purpose built ice capable cruise ship carrying just 98 passengers, made only the 33rd full passage of the historical Northwest Passage. By 2007 the cruise industry had established a regular pattern of activity that saw up to three crossings of the Northwest Passage a year but still using purpose built ice capable cruise vessels. The cruise itineraries for these types of vessel broadened to include a greater number of locations being visited. Stewart and Draper observed that

> *"the trends suggest that the cruise tourism industry in Arctic Canada has moved beyond its infancy and is now entering a maturing phase, with increased numbers of vessels, more regular and predictable patterns of activity, and the forging of new and more demanding routes."*

Since 2008 the trend that was mooted has occurred. A trend that not only has seen a growth in the market for cruise activity utilising specialist ice capable vessels but also has seen the major international cruise corporations capitalising on this market by offering cruises on their fleet of non ice specialist vessels,

2.3.4 Arctic Shipping Accidents

The AMSA report report (2009) among other papers provides a good synopsis of the trends and nature of shipping accidents. These are detailed below in Figures 2 and 3.

Vessel Type	#
Bulk Carrier	37
Container Ship	8
Fishing Vessel	108
General Cargo Ship	72
Government Vessel	11
Oil/Gas Service & Supply	1
Passenger Ship	27
Pleasure Craft	0
Tanker Ship	12
Tug/Barge	15
Unknown	2

Primary Reason	#
Collision	22
Damage to Vessel	54
Fire/Explosion	25
Grounded	68
Machinery Damage/Failure	71
Sunk/Submerged	43
Miscellaneous	10

Month	#
JAN	16
FEB	35
MAR	30
APR	6
MAY	15
JUN	18
JUL	39
AUG	22
SEP	31
OCT	35
NOV	23
DEC	23

Year	#
1995	35
1996	53
1997	23
1998	19
1999	21
2000	19
2001	31
2002	30
2003	28
2004	34

Figure 2 –Accidents and incidents in the Arctic 1995 to 2004 (Source AMSA, 2009)

The statistics shown in *Figure 2* show that during this period that there were 27 ‘passenger ship’ accidents and incidents of which formed just 9 percent of the total accidents and incidents reported. The numbers show that by year that the occurrence of these ‘accidents’ is general fairly constant with the monthly distribution showing some seasonality. More importantly a key ‘primary reason’ listed is that of grounding. This was the identified reason for the *Costa Concordia* accident though factors behind the grounding have yet to be fully established. One hypothesis being offered up is the practice of providing passengers with close views of iconic coastlines.

The geographical location of these ‘accidents’ shows that most of these up to 2004 have occurred on the periphery of the Arctic basin and have not occurred along the envisaged Arctic routes such as the NWP, NSR, and TSR (Figure 3).

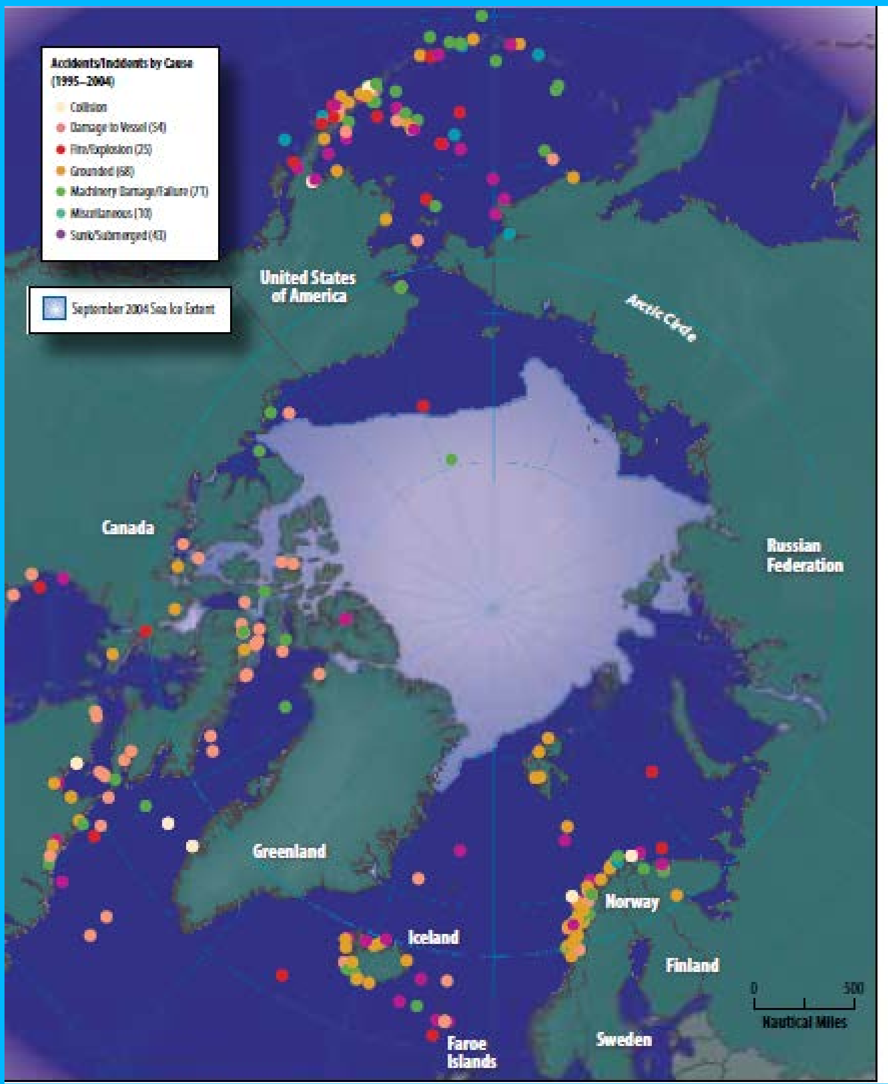

Figure 3 – Accidents and incidents in the Arctic 1995 to 2004 by geographic location. (Source AMSA, 2009)

The findings of the AMSA Report of 2009 were particular useful to highlight the areas of perceived need for attention in the Arctic marine transportation industry over the coming decades. Where these have not arisen elsewhere in the current report, we here re-iterate those most relevant to this study in full as additional background to our observations[15].

[15] Arctic Council. 2009. Arctic Council – Arctic Marine Shipping Assessment [AMSA] Report 2009

"Exploration and development of new Arctic natural resources take place in continually changing and hugely complex physical, economic, social and political environments. Few (if any) predictive/forecast capabilities of this broad scope and magnitude are available to provide quantitative information on these global sectors interacting together (and their relationships to Arctic marine transport requirements)".

"A large number of uncertainties define the future of Arctic marine activity. These uncertainties include: the legal and governance situation, degree of Arctic state cooperation, climate change variability, radical changes in global trade, insurance industry roles, an Arctic maritime disaster, new resource discoveries, oil prices and other resource commodity pricing, multiple use conflict (indigenous and commercial) and future marine technologies".

"Increased marine traffic in the central Arctic Ocean is a reality - for scientific exploration and tourism. The future holds increasing exploration voyages, plausible increases in tourism and fishing and plausible trans-Arctic voyages in summer on an experimental basis".

"A lack of major ports and other maritime infrastructure, except for those along the Norwegian coast and Northwest Russia, is a significant factor (limitation) in evolving and future Arctic marine operations. There are significant linkages between infrastructure and to most environmental protection and marine safety measures and strategies".

"Based on the information provided, significant portions of the primary Arctic shipping routes do not have adequate hydrographic data, and therefore charts, to support safe navigation. This appears most critical in the Canadian Archipelago and the Beaufort Sea and possibly other areas in the Arctic; at the same time the Russian Federation has broadly identified a requirement for updated hydrography in its Arctic waters. In addition, expansion of the current routes is required to allow alternative courses when hazardous ice conditions are encountered, for entry to points of refuge when necessary, and to support access to natural resources".

"Arctic Maritime Traffic Awareness - There are few systems to monitor and control the movement of ships in ice-covered Arctic waters as an effective way to reduce the risk of incidents, particularly in areas deemed sensitive for environmental or cultural reasons".

"There are serious limitations to radio and satellite communications for voice or data transmission in the Arctic because there is not complete satellite coverage of the region".

"There is no binding requirement to implement the recently developed and adopted International Association of Classification Societies (IACS) Unified Requirements concerning Polar Class and the December 2002 IMO Guidelines for Ships Operating in Arctic Ice-covered Waters; consequently polar vessel construction standards are unevenly

applied".

"For safe operations, ships navigating in the Arctic need the same suite of meteorological and oceanographic data, products and services as in the other oceans plus a comprehensive suite of data, products and services related to

sea ice and icebergs. As the shipping season becomes extended, significant increases in resources will be needed to expand the information services accordingly".

"Emergency response capacity for saving lives and pollution mitigation is highly dependent upon a nation's ability to project human and physical resources over vast geographic distances in various seasonal and climatic

circumstances. The current lack of infrastructure in all but a limited number of areas, coupled with the vastness and harsh environment, makes carrying out a response significantly more difficult in the Arctic. Without further investment and development in infrastructure, only a targeted fraction of the potential risk scenarios can be addressed".

"The operational network of meteorological and oceanographic observations in the Arctic, essential for accurate weather and wave forecasting for safe navigation, is extremely sparse". (All quotes from AMSA 2009).

2.3.5 The Arctic event simulation scenario

The Italian authorities are still completing their investigations with regard to the Costa Concordia and judicial processes so our simulation will limit itself to the facts as highlighted above and also to the published lessons learnt to date from national and international organisations, stakeholders and government bodies.

The summary principal elements of the Costa Concordia disaster to be considered are provided in Box 6.

Box 6

- Release of oil from ruptured fuel tanks;
- Landfall and contamination by oil or fuel oil;
- Construction and structural integrity issues;
- Safety at Sea - drills and life-saving equipment, passenger safety;
- Effect on tourism industry;
- Significance of hydrographic charting and natural hazards to shipping;
- Communication critical at all levels;
- Emergency rescue services - infrastructure needs;
- Hazard to shipping and salvage difficulties.

As above for our study of the oil rig disaster scenario, we have compiled a table to illustrate what areas of Arctic activities might be seen as affected as a result of a shipping/Arctic event over the next 30 years time.

Table 2 - Preliminary review of how the predicted results of long-term climate change in the Arctic are likely to affect (enhance, augment, modify) key impact parameters of a major shipping tourism/transportation event.

	Less ice cover	**Greater ice mobility**	**Thinner ice cover**	**Focused extreme weather**	**Sea temperature rise**
Release of oil from ruptured fuel tanks	Spills can travel greater distances	Greater difficulty in dealing with spill products?	Sub-ice spill more likely to reach surface. Sub-ice spill accumulation beneath ice may be less of an issue as it may escape through breaches in ice-cover.	Cyclonic weather systems will affect marginal/coastal seas, so will be most severely affected. Both natural redistribution and dispersal are increased. Spills may travel greater distances via enhanced surface current activity.	Change will not be at a rate to make any difference to evaporation/dispersal
Landfall and contamination by oil or fuel oil	Wider distribution of contaminants along	No specific significant effect?	No specific significant effect?	Enhanced difficulty in dealing with/clearing spillages	No specific significant effect?

	shoreline				
Construction and structural integrity issues	Ice-classification for vessels must be upheld, not reduced	Ice-classification for vessels must be upheld, not reduced	Ice-classification for vessels must be upheld, not reduced	Vessel maintenance and safety issues	No specific significant effect?
Safety at Sea - drills and life-saving equipment	Specific design for operations needed	Specific design for operations needed	Specific design for operations needed	Specific design for operations needed	No specific significant effect?
Affect on tourism industry	Greater access to extended areas necessitates greater support	Greater access to extended areas necessitates greater support	Greater access to extended areas necessitates greater support	Reduced interest of visitors	No specific significant effect?
Significance of hydrographic charting and natural hazards to shipping	Calls for greater awareness of need for appropriate charting and data maintenance	Need to chart ice-related issues, currents, pathways, ice-edge limits/patterns	Need to chart ice-related issues, currents, pathways, ice-edge limits/patterns	Observational needs and mapping for meteorological effects (e.g., currents)	No specific significant effect?
Communication critical at all levels	Maintenance and upgrade of SOLAS code specific to the Arctic	Direct communications may be hampered. Access by other vessels to site may be more hazardous	No specific effect, unless any (temporary?) comms would require ice station	Could restrict direct access to site	No specific significant effect?
Emergency rescue services - infrastructure needs	No specific significant effect? Different rescue craft needed?	May hinder operations	No specific effect, unless any (temporary?) comms would require ice station	Could restrict direct access to site	No specific significant effect?
Hazard to shipping and salvage difficulties	Greater access provided to (salvage/recovery) site.	Increase in difficulty for operations	Possible reduction in setting up ice station	Could restrict direct access to site	No specific significant effect?

2.4 Comparable event simulation effects on fisheries

It has proved hard to develop a simulation scenario of a fisheries event of comparable impact on the fisheries sector as we have for the Deepwater Horizon event regarding the oil sector and the Costa Concordia event regarding the tourism/shipping sector. Most of the events imagined for the fisheries sector have considered impacts and stress visualised using 'fall-out' effects from major events such as fish stock collapse and /or rapid demand increase. Shortages in other food markets could arise due to collapse of other fish stocks and drop in agricultural production caused by climate change induced extreme weather events and general warming. Increased global food demand would be due to the increasing population trends and the changes in food consumption patterns (more proteins and more food in general). Such an increase in demand is likely to be gradual rather than sudden, but if several rapid changes coincide and reinforce each other we may have abrupt changes as well. The scale of the event and the different rate of its effects are key factors and we will need to consider these further in subsequent ACCESS deliverables. the next report. One possibility would be to consider the impacts on the operation of a fisheries management organization, if instated, for new fisheries in the Arctic Ocean following climate change?

3 Arctic Ocean Regulations - Reflections on potential effectiveness of existing regulatory systems for simulated Arctic disaster events.

Our simulations for the two major maritime events in the Arctic discussed above allows us to make a series of observations regarding the unlikelihood of current legislation being fully effective in achieving satisfactory governance in an Arctic Ocean experiencing the effects of long-term climate change.

The examples we have used in this summary represent the less likely, "extreme end", 'disaster'-type events, but this was deliberate in that we needed to consider all possible effects within a spectrum of likely events, within which less impact events could be readily contained.

These observations are necessarily qualitative, and at this stage in the ACCESS project also tentative, but we intend to use the second half of the project (2013-2015) to underpin, expand and strengthen our findings in order to provide sustainable strategic governance options for review by the wider community. This report can only make observations and provide questions, as well as highlight critical areas of governance which need to be addressed across the different sectors of ACCESS. We will use these pointers and the findings of our partners across all the principal work packages to focus the development of clear governance options for our next report. Some specific comments to be extracted from our findings to date are provided in Box 9 - at this juncture, perhaps, timely warnings of how legislation and regulatory systems not only have to be put in place, but also to be maintained and continually updated.

Box 9 - Observation and Comment

- The most critical areas of attention where our findings point at a need for close observance, review, revision, and implementation are: ensuring infrastructure is in place to deal with worst-case scenarios for each industry which operates in the Arctic; ensuring that human life, environment and indigenous communities are affected as little as possible; the emplacement of as standardised a series of regulatory systems and mandatory codes/controls on living and non-living resource exploitation and transportation as possible; the existence of monitoring procedures to ensure that appropriate implementation of legislation is maintained; and finally, the provision for regular, independent review and update of regulations in place.
- This report will continue to be reviewed during the lifetime of ACCESS, in conjunction with the evaluation of existing regulatory systems and preliminary findings related to governance options (Deliverables D5.11 and D5.21) . All of the principal ACCESS work packages will continue to contribute to this process, as they have done so thus far. These results will be integrated in the preparation of one of the project synthesis deliverables (D5.41, *'Production of summary of governance options over ACCESS time period'*.)
- The findings of commissions set up to review the effectiveness of regulations, guidelines, agreements, legislation, treaties and control systems in preventing and coping with events such as Deepwater Horizon and Costa Concordia were unanimous in criticising the way the regulations were not implemented appropriately as much as criticising what instruments were in place.
- For the Arctic Ocean, even more so than in other regions, the simple existence of regulations and guidelines will not be enough to ensure safety for the environment and the people who live and work in it, and the maintenance and the application of any regulatory systems in place in a coordinated and effective way is of paramount importance.
- Forward projection of, and continual revision and update of existing regulations, guidelines, agreements, legislation, treaties and controls has to be a part of any legislative system, and in particular in the Arctic environment. This continual process is essential.

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