# Systemic risk of maritime-related oil spills viewed from an Arctic and insurance perspective


**Abstract**

There is a wish for economic development in the Arctic, especially in relation to the region's untapped marine and hydrocarbon resources. However, such developments are inherently risky, entailing the possibility of trade-offs and potentially jeopardizing a fragile and pristine natural environment which provides multiple sources of well-being to the Arctic's four million inhabitants. When the risks of economic development are evaluated, they are usually assessed on a micro (enterprise risk) and/or meso level (portfolio risk, such as an industry). Systemic risk is considered to a much lesser degree. There is also limited discussion about mitigation methods, including the role of insurance in dealing with the consequences of failures, such as oil spills. The aim of this study is, therefore, to explore the systemic risk of maritime-related oil spills in general and place the findings in an Arctic and insurance perspective. The study is based on secondary data relating to major maritime-related oil spills from drilling and shipping. Two analytical frameworks were employed, one explaining the scaling of risks, and another showing the interplay between subsistence and monetized economies in tandem with their institutional, environmental, social and cultural context. The findings suggest, if the worst-case scenario materializes, that maritime-related oil spills may have social/cultural, environmental, and economic impacts, in addition to security/policy implications, as well as affecting businesses involved in the disaster and their partners. This study has academic implications since there are, so far, limited studies carried out on systemic-level risk, but it also has policy relevance, for instance for local and regional authorities and international bodies, such as the Arctic Council, in terms of holistic risk-assessment and its recommended use of appropriate decision-making and evaluative frameworks such as ecosystem-based management.



**Keywords:** Arctic; insurance; maritime; systemic risk; oil spill

## 1. Introduction

Arctic boundaries differ depending on who defines the boundary and for what purpose. For instance, the Arctic can be defined based on ecological, geographical and/or physical characteristics. The Arctic Monitoring and Assessment Programme (AMAP) working group of the Arctic Council has defined the maritime boundary (AMAP, 2008) (see Fig. 1). For the purpose of this study the focus will be on the high north, meaning areas where maritime activities are expected to increase due to a retreat of summer ice, thus opening up new opportunities for off-shore energy production and shipping.

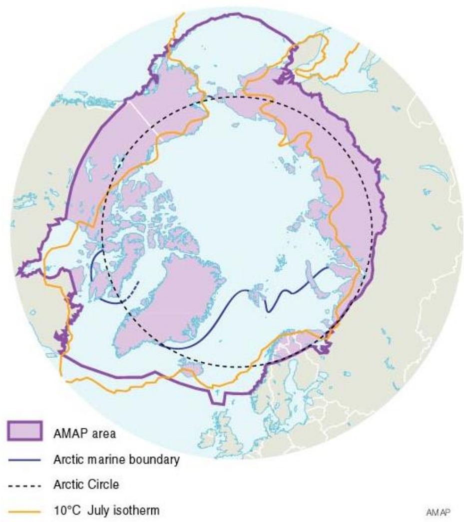


**Fig. 1.** The Arctic maritime boundary (AMAP, 2008).

Climate change is causing fundamental changes in the Arctic and the rate of global warming in the region is twice the global average (Anisimov et al., 2007). This means that there is a disproportionally high risk for Arctic ecosystems (IPCC, 2018), and there is strong evidence that various species, ecosystems, and communities are, and will be, exceptionally vulnerable and adversely affected (Anisimov et al., 2007). Those impacted will not least include indigenous peoples since Arctic ecosystems provide substantial sources of nutrition, cultural, social and economic values (AMAP, 2015; IPCC, 2018), with their livelihoods depending on traditional diets harvested from the land and sea (AMAP, 2015). Other impacts include retreat of the ice sheet of Greenland's glacier and ice volume in the Arctic, discharge of rivers into the Arctic Ocean, and thawing and warming of permafrost with infrastructural consequences for communities as well as injury and death of people owing to weather events and temperature extremes (Anisimov et al., 2007). The relatively pristine Arctic environment (Glomsrød, Duhaime, & Aslaksen, 2015) is also at risk because of manmade pollution including black carbon emissions (CCAC, 2017) and plastics (Cózar et al., 2017).

The Arctic population itself might be small, at roughly four million (Arctic Council, 2016a), but the region is increasing in importance in an economic and geopolitical sense, with the potential to develop significant amounts of oil, gas, and mineral resources (Anisimov et al., 2007). Opportunities are also recognized in fisheries, shipping and logistics, and tourism (Emmerson & Lahn, 2012). Possibilities to navigate through the Northwest Passage and the Northern Sea Route will increase due to loss of summer sea-ice (Anisimov et al., 2007; Emmerson & Lahn, 2012), and in August 2018 a container ship owned by shipping conglomerate Maersk was the first one to navigate the Northern Sea Route unassisted (Reuters, 2018). For the Arctic's resources to be utilized infrastructure development is needed (Kaiser et al., 2018), and the region's investment needs over the next two decades are estimated to be US$1 trillion (Guggenheim, 2016). Economic development of the Arctic should, however, not jeopardize the natural environment, and in order to reach this goal three principles are emphasized; sound science, prudent management based on conservation, and a responsive public process (Arctic Council, 1999).

> *"For me - and for most Alaskans - the choice isn't either-or. We believe that by doing development right, we can have good jobs and a growing, healthy economy and protect our environment (Tony Knowles, 1999)".*

Current studies on risk in the Arctic linked to marine-related oil spills have tended to focus on impacts to economic sectors and companies (Emmerson & Lahn, 2012; Jóhannsdóttir & Cook, 2015). In the context of the sustainability of marine-related economic developments in the Arctic, there is a need for a broader discussion about risk (Arctic Today, 2019), since economic developments could lead to potentially negative consequences for the sustainability of the region and a worst-case scenario may put a lot of strain on local communities, especially small and indigenous communities in the region (Green, Kilcullen, Long, Samuel-Horsfall, & Schanne, 2016; Taylor, 2014). Increased economic activities in the Arctic, such as trans-Atlantic or destination shipping, or offshore energy developments (SINTEF, 2011), will exacerbate the risk of major pollution incidents such as oil spills (AMAP, 2015). A significant oil spill may have more serious consequences in the Arctic than in other parts of the world, given factors such as the fragility of Arctic ecosystems, the region's small population (Arctic Council, 2016a), subsistence ways of living for indigenous communities (Fall, 1991), challenging weather conditions, (EPPR, 2017)", infrastructure limitations (Emmerson & Lahn, 2012; Skinner & Reilly, 1989), limited search and rescue capabilities, and a lack of local level preparedness (Arctic Council, 2018c). It has, furthermore, been pointed out that oil spills in ice infested waters are harder to deal with than open water, and that Arctic waters "might never recover from an environmental catastrophe like the one in the Gulf of Mexico" (Stotts, 2010). Issues with liability have been emphasized, where it is claimed that international conventions or international agreements do not exist that "establishes a liability system for claims for compensation or the cost of cleaning up pollution for an offshore oil and gas incident either in the Arctic or anywhere else in the world" (WWF, 2015, p. 7). In addition, given Arctic conditions, clean-up costs are likely to be significantly greater than in less remote areas with more developed infrastructure, and milder weather conditions (Bonnieux & Rainelli, 1993).

It is particularly important to discuss Arctic risks that are of such a scale that they may have systematic consequences if they materialize through human or technological failures. Risks in various forms will exist in today's societies, but must be recognized in order that they can be mitigated and managed (Flyvbjerg, 2014; Flyvbjerg, Bruzelius, & Rothengatter, 2003). In recent years, increased attention has been paid by policymakers to the general concept of risk in relation to Arctic ecosystems and local communities. For example, Lilja Alfreðsdóttir, Iceland's Minister of Education, Science and Culture, has emphasized the importance of nature protection by highlighting the Paris Agreement and three legally binding Arctic agreements; Agreement on Enhancing International Arctic Scientific Cooperation (signed 2017), Agreement on Cooperation on Marine Oil Pollution Preparedness and Response in the Arctic (signed 2013), and Agreement on Cooperation on Aeronautical and Maritime Search and Rescue in the Arctic (signed 2011) (Arctic Council, 2017a; Lilja Alfreðsdóttir, 2018). However, despite recognition, the main way of mitigating risks in industrialized societies is through the mechanisms of the insurance system. Currently, very limited knowledge exists on insurance related to Arctic-specific risks associated with economic development, especially hydrocarbon projects (Emmerson & Lahn, 2012; Jóhannsdóttir & Cook, 2015).

The aim of the study is to explore systemic risk of maritime-related oil spills in particular and place the findings in an Arctic and insurance perspective. The research questions proposed are:

- How is systemic risk defined?
- What are the consequences when failures occur involving major marine-related oil spills?
- How might the consequences of major oil spills caused by failure look like in the Arctic?
- What is the role of insurance in cases of major marine-related oil spills?

The paper is structured in the following way. Section 2 includes a literature review and overview covering systemic risk, systems failure, high reliability organizations, and mega projects, with these topics shedding light on the magnitude and causes of failures. The section also discusses insurers' views on systemic risk, the Arctic Council's perspective on the topic in relation to oil spills, and the International Maritime Organization's (IMOs) view on these issues. Section 3 outlines the research method and analytical frameworks employed. Section 4 presents the findings, and sections 5 and 6 cover the discussion and conclusions.

## 2. Literature review and overview

### 2.1 Systemic risk and systems failure

There is no universal definition of risk, but drawing from the Intergovernmental Panel on Climate Change (IPCC) it is the "potential for adverse consequences from a hazard for human and natural systems, resulting from the interactions between the hazard and the vulnerability and exposure of the affected system" (IPCC, 2018, p. 33). In this study, the focus is on maritime-related hazards of oil spills. In cases of systemic risk there is a trigger event, a tipping point, which can be an institutional failure or economic shock that "causes a chain of bad economic consequences – sometimes referred to as a domino effect (Schwarcz, 2008, p. 198)". The chain of consequences can be "financial institutions and/or market failure" or "significant losses to financial institutions or substantial financial-market price volatility" in less severe cases, but the impact will have consequences for either institutions or markets, or both (Schwarcz, 2008, p. 198)". Bank collapses are seen as symbols of systemic risk according to Schwarcz (2008). This was very much evident in the banking crisis of 2008, such as in the case of Iceland where the whole banking system collapsed (Árnason, Nordal, & Ástgeirsdóttir, 2010). So as to hedge against systemic risk, the strategy of investors is typically to diversify their investment portfolios. Theoretically, institutional systemic risk can be cancelled out if the risk "is negatively correlated, or uncorrelated, with market risk", but if it is "positively correlated with markets" it cannot be cancelled out (Schwarcz, 2008, p. 200).

Based on the above understandings, Schwarcz (2008) has proposed a definition of systemic risk, which he regards as a ***risk to*** a financial system, not a ***risk within*** a system. This delineation aligns with the London School of Economics which distinguishes between shocks from outside a system (exogenous risk) and shocks from within a system (endogenous risk) (Danielsson & Shin, 2002). Schwarcz's (2008, p. 204) definition is as follows:

> *the risk that (i) an economic shock such as market or institutional failure triggers (through a panic or otherwise) either (X) the failure of a chain of markets or institutions or (Y) a chain of*

*significant losses to financial institutions, (ii) resulting in increases in the cost of capital or decreases in its availability, often evidenced by substantial financial-market price volatility.*

Structural flaws embedded in complex networks are another way of defining systemic risk (Goldin & Vogel, 2010; Humphreys & Thompson, 2014). “Thus, higher degrees of systemic risk increase the probabilities of breakdowns, accidents, and adverse consequences in ways that are beyond the control of any given actor in the system” (Humphreys & Thompson, 2014, p. 880). Market and institutional systemic risk can therefore not be viewed in isolation from each other (Schwarcz, 2008), and a feedback loop between systems and portfolios should be considered (Baue, 2017; Burckart, Lydenberg, & Ziegler, 2016). Failure of a system happens because of interlinkages within a system, causing an entire breakdown rather than failure of individual parts or components, which leads to widespread and severe economic consequences (PwC, 2014; The Systemic Risk Centre (SRC), 2013; Zhang, 2018).

Collective interests of a group or society might be set aside, even though collective actions might prevent systemic risk and stabilize the system. This is despite the external costs of systemic failure, such as social costs, which otherwise might have to be internalized (Schwarcz, 2008). According to Schwarcz (2008), this then results in the tragedy of the commons, where the market players reap the most benefit of given resources without taking notice of the welfare of others who may bear the cost of the outcomes, such as unemployment or widespread poverty, which may in turn lead to increased crime. Furthermore, market players may also discount the potential impacts of systemic risk, because they are so rare in comparison to other types of market risks (Schwarcz, 2008). Schwarcz (2008) therefore highlights the necessity of regulating systemic risk, while ensuring that the economic costs of regulation do not exceed the benefits. With the aim of protecting the whole system by preventing or internalizing systemic risk, regulation is needed (Humphreys & Thompson, 2014; Schwarcz, 2008). Otherwise the cost will be externalized, as the members of the market will first and foremost protect themselves as they have limited or no incentives to limit risk taking in order to “reduce the danger of contagion for other firms” (Schwarcz, 2008, p. 206).

Within the financial community the idea of an “universal” investor has emerged, but such an investor would take into account the whole economy, not solely the performance of specific securities. Externalities to specific investments are believed to affect other investments throughout the investment portfolio (Burckart et al., 2016, p. 3). To bridge between current investment practices and systems-level thinking there are ten tools investors can use, which are 1) additionality, 2) diversity of approach, 3) evaluation, 4) geographic location, 5) interconnectedness, 6) policy 7) self-organization, 8) solutions, 9) standard setting, and 10) utility.

In case of investments, the focus has mainly been on enterprise level risks or risks in investment portfolios (meso level), while investors are just recognizing systemic risk (macro level), and to a lesser extent existential risk (cosmic level) (Thurm, Baue, & Lugt, 2018), which is essential to deal with so-called wicked problems than cannot be tamed, such as climate change or droughts (Batie, 2008). The career risk (nano level) focuses on risks faced by individuals (including investors) that focus on maintaining “business-as-usual” and are thus “dis-incentivized from pushing for the degree of transformation needed” in investments (Thurm et al., 2018, p. 38). When analyzing a technically complicated system, it can be of use to strip the system into layers so each aspect can be viewed separately and in the context of the upper layer(s) of the system. The risk system proposed by

Reporting 3.0[1] has five levels of risks (see Fig. 2). The hierarchical pyramid ranges from the nano to cosmic level (Thurm et al., 2018). The layered approach is also conducted in the TeCSMART framework which looks at the following layers: equipment, plant, management, market, regulatory environment, governmental environment, and society (Zhang, 2018).

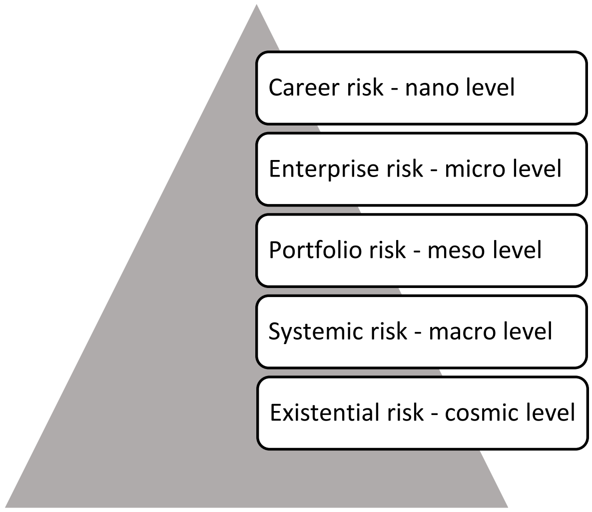


**Fig. 2.** Business Model Transformation Scaling Progression adapted from Reporting 3.0 by the author (Thurm et al., 2018, p. 49).

Sometimes the claim is made that systems are too big to fail, such as energy production (Lakoff, 2010) or financial systems (Árnason et al., 2010). Nevertheless, history is littered with cases of systemic failure (Flyvbjerg, 2014). In order to understand and manage systemic risks, various research projects have been proposed, including studies focused on offshore oil and gas operations (The National Academies of Sciences, 2017). Viewing systemic risk solely as a risk to a financial system may be considered too limited, since systems are typically comprised of a multitude of environmental, social, financial, and technological components (Baue, 2017; Burckart et al., 2016; King, Schrag, Dadi, Ye, & Ghosh, 2015; Lloyd's Register Foundation, 2017). Relatively recent failures of broad socio-technical systems include the Piper Alpha disaster in 1988, the Northeast Blackout in the parts of the Northeastern and Midwestern United States and the Canadian province of Ontario in 2003, the space shuttle disaster in 2003, the BP Deepwater Horizon oil spill in 2010, and the Volkswagen Emissions Scandal (2016) (Zhang, 2018). Such occurrences suggest that systemic risk is not infrequent and needs to be discussed on a broader level than from just the financial and/or market perspective due to the high interconnectivity of systems (Lloyd's Register Foundation, 2017).

To understand how organizations fail, causing systemic failure, the idea of high reliable organizations (HROs) carrying out high-reliable operations have been discussed (Deepwater Horizon Study Group, 2011; Roberts & Bea, 2001). These organizations will run complicated systems, such as nuclear power plants, chemical plants, nuclear-waste storage, electric grids, financial networks, and telecommunication and computer networks (Roberts & Bea, 2001). Systemic failures are in most cases caused by human or organizational errors (80%) (Bonnieux & Rainelli, 1993), while design errors or other factors cause only around 20% of the failures. Five building blocks are proposed that may

[1] Reporting 3.0 is defined as a global work-ecosystem that aims to scout out and accelerate reporting innovations for the purpose of bringing global capitalism onto a sustainable path and make a regenerative and inclusive economy reality.

mitigate systemic failure and catastrophes and enhance reliability in organizations. These are structural failure, efficiency versus reliability, core competencies and incompetencies, sense-making, and group performance and heedful interaction (Roberts & Bea, 2001). To address organizational weaknesses that may cause systems to fail organizational norms need to acknowledge that technological failures occur and there might be other potential causes of significance. Furthermore, organizational structure needs to be fluid where bureaucratic hierarchical structures may have to be set aside if conditions change. There has to be an understanding of what signifies as changing conditions; mechanisms of reliability as opposed to efficiency need to be incorporated into the organizational culture and core competencies that may turn in to incompetencies in situations of emergency need to be recognized. Additionally, people capable of making sense of the situation may have to be brought in to question perceptions made; and organizational members need to be trained in heedful interaction, thus enhancing group performance (Roberts & Bea, 2001).

The features of systemic risk and potential for systemic failure is particularly evident in connection with megaprojects. “Megaprojects are large-scale, complex ventures that typically cost a billion dollars or more, take many years to develop and build, involve multiple public and private stakeholders, are transformational, and impact millions of people” (Flyvbjerg, 2014, p. 3). Examples of megaprojects are infrastructure projects, e.g. airports or seaports, offshore oil and gas extraction, large container or cruise ships, mining, and so on. In an Arctic context, megaprojects might not benefit a large number of people directly, but they are likely to also do so indirectly, for example through increased local economic activity. These projects are carried out for various reasons, such as political (monuments), technological (big, tall, fast, long), economic (job and money making), or aesthetic (beauty of design) (Flyvbjerg, 2014). However, these types of projects are characteristically risky for various reasons, such as in terms of planning, leadership, multi-actor involvement, and conflicting interests. For these reasons, “misinformation about costs, schedules, benefits, and risks is the norm”, where benefits are overestimated, and costs underestimated, and megaprojects are more prone to being unsuccessful than successful in terms of these factors, resulting in “net loss to the economy, instead of gain” (Flyvbjerg, 2014, p. 8; 12). There are, however, some positive signs in relation to the management and regulation of megaprojects, including new legislation, good governance practices, and public hearings for cases of failures (Flyvbjerg, 2014), but public policy needs to also address systemic failures, “through regulation, economic intervention and incentives as well as improved communication” (Lloyd’s Register Foundation, 2017, p. 28).

### 2.2 The Arctic Council, systemic risk and oil spills

Member states of the Arctic Council are Canada, Finland, Iceland, the Kingdom of Denmark, including the Faroe Islands and Greenland, Norway, Russia, Sweden and the Unites States, and six Arctic Indigenous Peoples international organizations have permanent participant status within the Arctic Council (Arctic Council, 2015). A vast amount of information exists on the webpage of the Arctic Council, including reports issued by the body’s various working groups. Searching the Arctic Council website, and its open access archive, for the concepts of “systemic risk” or “systemic failure” resulted in zero items in the case of the website, but eight items from the archive. Further screening of the documents revealed two items of relevance, i.e. [environmental] problems in the Russian Arctic and transboundary causes and effects (Arctic Council Secretariat & Russian Delegation to the Arctic Council, 2010, p. 2), and Arctic transportation infrastructure (Institute of the North, 2012).

The Arctic Council’s archive, however, offers greater information about oil spills with a total of 381 items found (Arctic Council, n.d.). A mind map in Mindjet MindManager 2018 was developed to get an overview of the search findings. Based on this analysis the main themes that surfaced were strategic plans of the Arctic Council, meetings and statements, task forces of the Arctic Council, agreements made, cooperation and risk assessments, various projects and reports, economic activities related to offshore oil and gas projects, as well as guidance and tools recommended or developed in the context of potential oil spills (Arctic Council, n.d.). Advanced searches of the Arctic Council archive using the terms “oil spill” and “social” or “indigenous” resulted in zero items.

The Arctic Council’s ministerial declarations from 2004 onward make it is evident that oil and gas, as well as shipping, are growing concerns, and that there is an emerging need for knowledge on these topics. Since 2006, the emphasis on engaging indigenous peoples into policy planning and implementation, as well as enhancing their adaptive capacity, has been on the rise, and from a systemic perspective new emphasis has been placed since 2013 on how to exploit the economic potential of the region, while at the same time managing conceivable harms to Arctic cultures and its environment. In addition, a recent report from the Arctic Council entitled *Digital resources* brings forth the importance of oil pollution prevention in the Arctic marine environment from offshore petroleum activities (Arctic Council, 2017d, 2018a), such as an agreement on cooperation concerning marine oil pollution preparedness and responses in the Arctic (MOSPA), technical analysis of circumpolar oil spill response viability, standardization as a tool for the prevention of oil spills in the Arctic, and implementation of a framework plan for cooperation on the prevention of oil pollution from petroleum and maritime activities in the marine areas of the Arctic. It is evident from the Digital resources report that the focus is on pollution preparedness and responses to oil and gas activities (Arctic Council, 2018a). There is less focus on oil spills related to shipping in particular although guidelines can be found, such as from the PAME working group of the Arctic Council, where the focus is on oil transfer, such as between vessels, or between vessels and the shore facility or vice versa (PAME, 2004).

Despite efforts it is apparent that more can be done to prevent oil spills in Arctic waters, and to enhance adequate response capacity to spills across the Arctic (PAME, 2011). Proceedings on Arctic transportation infrastructure, response capacity and sustainable development highlights a limited focus on the social aspect of the topic, although it is stated that “[s]tates can consider the impact of infrastructure on social and economic development“ (Institute of the North, 2012, p. 19). Increased traffic in Arctic waters is expected to increase the likelihood of incidents, and thus the risk becomes greater. It is emphasized that the increased likelihood of incidents should influence decisions on infrastructure investments. However, Arctic investment (i.e. vessels, harbors/ports, airports, communication/navigation and workforce) is considered to be riskier than elsewhere, and as a result infrastructure investment may be quite limited unless extraction is considered economically viable. Furthermore, risk assessment should be a part of a safety management system adopted across all Arctic nations, but there are questions about what risks should be assessed, on what scale and who is responsible for the risk assessment and consequently for negative impacts from incidents (Institute of the North, 2012).

In relations to oil and gas activities further work and collaboration are needed, such as engagement of indigenous peoples, risk assessment/analysis, and emergency preparedness and response (Arctic Council, 2016c), all of which are critically important if a systemic risk materializes related to marine oil spills. Furthermore, knowledge about the long-term impacts of economic development on the Arctic region and on Arctic citizens such as from pollution or overuse of resources, are still lacking (Arctic Council, 1999). It should however been noted that a map and preparedness database for small Arctic communities has been created, representing “tangible resources remote Arctic communities can use“ in cases of oil spills (Institute of the North, n.d.). Although, the database offers a valuable overview of multilateral and national agreements, recommendations, guidelines, strategies, interactive maps, and databases covering Arctic communities e.g. size of population, latitude and longitude, the practical use of the database is not evident in cases of oil spills.

One of the Arctic Council's goals, presented in the Arctic Marine Strategic Plan 2015-2025 (AMSP), and approved at a ministerial meeting in Iqaluit, Canada in 2015, is to "[e]nhance the economic, social and cultural well-being of Arctic inhabitants, including Arctic indigenous peoples and strengthen their capacity to adapt to changes in the Arctic marine environment" (Arctic Council, 2017b, p. 2). Nevertheless, the potential for conflicts of interest are also raised, for instance between fisheries, local community subsistence livelihoods and companies working in oil and gas extraction (ARAF Chair, 2016; Arctic Council, 2016b). A systematic disconnection was observed in 2015 between exploitation, cultural and environmental interests, and a power imbalance between stakeholders (Arctic Council, 2016b). This was evident in discussions about using standardization as a tool for the prevention for prevention of oil spills in the Arctic. Concerning a standardization process in the petroleum industry, stakeholders taking part in a hearing about the standard draft included "relevant authorities, organizations and industry groups / associations", although proposals for new standards may come from "individuals, NGOs, companies [or] industry associations (Arctic Council, 2017c)". The aim of the standardization process might also be to work "in partnership with key stakeholders", but it is not transparent who these stakeholders are and what is at stake from their viewpoint (Det norske Veritas, 2013, p. 40). It is, however, apparent that research on "oil drilling and transportation of oil and other hazardous goods in Arctic waters", as well as "possibilities for increased cooperation in the field of culture in the different parts of the Arctic region" is still needed (Arctic Council, 2014).

### 2.3 Insurers' view on systemic risk

In a 2014 report, initiated by the WWF and RSA Insurance Group plc., the focus was on emphasizing how environmental systemic risk is understood by the insurance sector, and if insurers can do more in taking such risk into account within their long-term strategies or the strategies of their customers' (PwC, 2014). Examples are provided on how man-made action can exacerbate issues, such as in the case of heavy rainfall in Chile in 2009, where deforestation caused low-grade nitrogen fertilizers to wash across farmland until the contaminated water reached to fish farms, resulting in algae bloom starving fish from oxygen and bringing about a multi-million dollar insurance claim (PwC, 2014). This example highlights the link between environmental and financial systemic risks. The insurance report therefore suggests that in order to detect and mitigate financial risk a deeper approach is required (PwC, 2014). For instance, if an oil tanker is lost at sea, the consequences might not be limited to the financial losses of the value of the ship and its cargo. Impacts might also include crude oil spills that could "have a profound effect on wildlife, on nearby coastline, on those who depend on fishing or tourism in the area and so forth" (PwC, 2014, p. 4).

In the insurance report systemic risks are characterized by (PwC, 2014, p. 4):

> *"… complexity, uncertainty, ripple effects and the potential for irreversibility. There may be little or no historical precedence to use as guidance. On many occasions the scale of the risk might only be revealed when the worst happens, but effective risk management can identify existing or potential interdependencies and seek to isolate risks, prevent contagion and mitigate damage."*

It is further noticed that natural catastrophes, e.g. weather related, or industrial/man-made incidents, such as pollution, can cause systemic risks (PwC, 2014). Environmental risk exposure has already been recognized by reinsurance companies and large insurance companies (PwC, 2014), while smaller insurance companies are not as well prepared to deal with these types of risks (Johannsdottir & Wallace, 2019b; Jóhannsdóttir, 2012a, 2012b). Therefore, it would be beneficial to approach environmental systemic risk on an industry-wide level (PwC, 2014). The insurance report states that stakeholders will gradually expect insurers to consider environmental systemic risk given the wide impacts these losses can have. Although, some industry-wide approaches and initiative are evident in this regard, e.g. the ClimateWise, Geneva Association and the UN Principles for Sustainable Insurance, it is underlined that more needs to be done for the greater good of the industry, those seeking insurance protection (PwC, 2014), and also society.

### 2.4 The International Maritime Organization, systemic risk and shipping in Arctic waters

Based on common interests the Arctic Council develops unified approaches and positions with regards to international organizations, including: The International Maritime Organization (IMO), the International Maritime Satellite Organization (IMSO), the International Hydrographic Organization (IHO), and the World Meteorological Organization (WMO), since collaboration with these institutions advances the safety of Arctic maritime shipping (Arctic Council, 2009). Furthermore, the IMO adopted the Polar Code, an international regime for ships operating in Polar waters in 2014. The Polar Code entered into force in 2017, but its significance relates to the protection of ships and people onboard, both seafarers and passengers, in harsh and inhospitable waters. The Polar Code has the potential to mitigate the risks of sailing in the Arctic by contributing to risk appraisal, going beyond the key factors used to determine insurance premiums (ship, navigating limits, insurance coverage, insured risk profile), however, various shortcomings have been identified, including lack of data, exclusion groups of vessels such as fishing vessels, omission of carried goods, and use of heavy fuel oil with associated air pollution and greenhouse gas emissions (Fedi, Faury, & Gritsenko, 2018). Some recommendations made in the Polar Code, e.g. concerning the management of ballast water, are also non-mandatory.

Related amendments, to make the Polar Code mandatory, have been made to the legally binding agreements of the International Convention for the Prevention of Pollution from Ships (MARPOL) and the International Convention for the Safety of Life at Sea (SOLAS) (IMO, n.d.-b). The Polar Code also addresses environmental issues, and aims to protect the environment, by preventing oil spills, invasive species, sewage, garbage, and chemical discharges (IMO, n.d.-a). Ship safety is emphasized through prescriptions concerning their design and construction, the types of equipment on board, and the operations and manning of ships, including navigation, certificates and manals, and required training (IMO, n.d.-c). Mandatory measures, and recommended provisions, are included regarding safety and pollution. According to the Polar Code, the ship master shall consider, when sailing in polar waters, issues such as navigation availability, ice conditions, available places of refuge, densities of marine mammals, national and international designated protected areas along the sailing route, as well as the remoteness from search and rescue (SAR) capabilities (IMO, 2015). In this context, it is important to highlight that oil spill response viability varies greatly throughout the year, with the situation better during summer months (July to October), when most areas are ice-free. However, during winter months', responses may not be as favorable. Location is another key aspect affecting likely response times. Oil spill responses are more favorable in the Bering Sea, Barents Sea, Norwegian Sea, Baffin Bay, Hudson Bay, and North Atlantic, while the situation is less favorable in other areas within the Polar region (EPPR, 2017).

## 3. Research method

For analysis purposes, two frameworks are employed to capture the hierarchical character and dynamics of various risks in an Arctic context, before a case study approach is applied to identify the systemic risk events associated with marine oil spills, including incidents in Arctic waters.

First, the Reporting 3.0 framework (Thurm et al., 2018, p. 49) (see Fig. 2), has been applied to the Arctic context (see Fig. 3). The schematic highlights how systemic risk, such as an oil spill, may transform into an existential risk for subsistence economies. Therefore, feedback loops between the subsistence and existential levels are integrated into the model. In addition, levels of risks increase from level-to-level, and higher risk levels at the base of the pyramid should take into account risks that are less broad in impact.

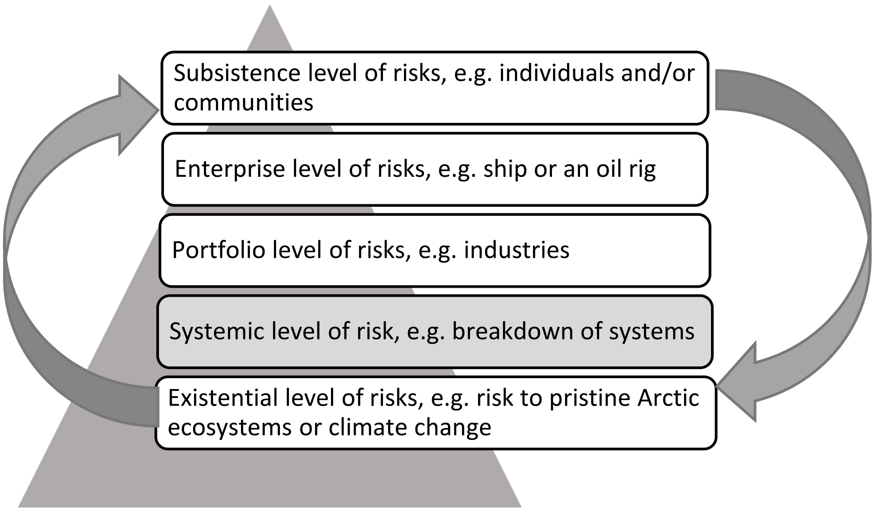


**Fig. 3.** Scaling of risks. Model developed by authors, inspired by the Reporting 3.0 Business Model Transformation Scaling Progression model (Thurm et al., 2018, p. 49).

Second, an unpublished conceptual framework showing the interdependence of subsistence and market economies in the Arctic (see Fig. 4), developed by a group of Fulbright Arctic Initiative (FAI) scholars, was employed (Larsen et al., under review by Global Policy). This conceptual framework explains how subsistence (non-monetized) economies, mixed economies and market (monetized) economies co-exist in the Arctic. The framework also highlights that economic activities may be on different scales, ranging from local to global. Furthermore, the framework places these economies in their institutional, environmental, social and cultural context (Larsen et al., under review by Global Policy). The framework allows for comparative analysis of Arctic economies, which is of importance since economic opportunities for market economies may entail risks for subsistence economies, or vice versa. Additionally, it enables a system level of analysis by recognizing the elements and complicated relationships presented in the framework. The FAI scholars also state the benefits of the framework, such as for different academic disciplines, for policy makers and practitioners, and for regions other than the Arctic, if these regions include the types of economies presented in the conceptual framework (Larsen et al., under review by Global Policy).

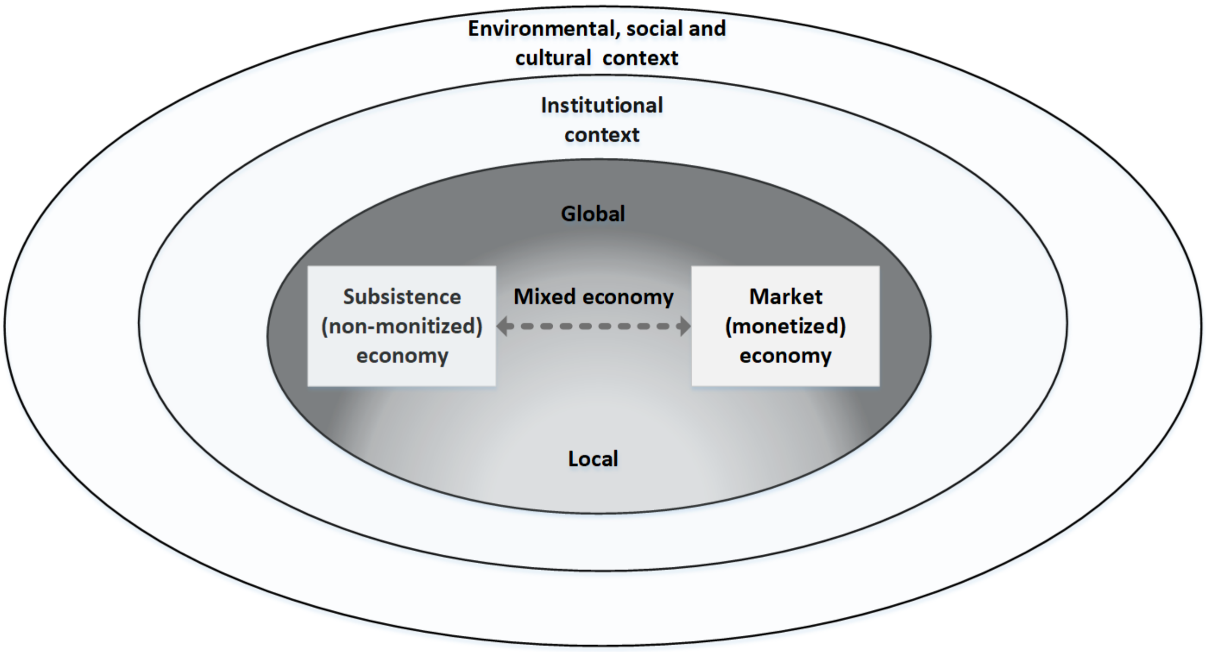


**Fig. 4.** Subsistence and market economies interdependence (Larsen et al., under review).

### 3.1 Case selection and data collection

It is relatively easy to come up with a list of major maritime-related oil spill disasters, since rankings are determined based on quantity or an estimation of oil spilled (ChartsBin, 2011; Encyclopaedia Britannica, 2018; Marine Insight, 2018; Mother Nature Network, 2010; The Telegraph, 2011). In this study, the cases were based on quantity and, if evident, their relevance for an insurance or Arctic context, such as the Deepwater Horizon and Exxon Valdez oil spills (Emmerson & Lahn, 2012; Rees & Sharp, 2011). Table 1. provide details on the selected cases. It provides the names of each case, location and causes of the spills, quantity of oil spilled, as well as year of the spills. The size of each spill might vary slightly depending on the particular source of information, but what should be noted is that the Deepwater Horizon is the largest, and the Exxon Valdez by far the smallest in terms of quantity of oil spilled. The smallest case in terms of quantity was Exxon Valdez, in 1989, with 11 million gallons of oil, and the largest was the Deepwater Horizon in 2010, where the estimated quantity was 210 million gallons of oil (ChartsBin, 2011; Encyclopaedia Britannica, 2018; Marine Insight, 2018; Mother Nature Network, 2010; The Telegraph, 2011). To highlight the dates of their occurrence, the oldest cases are in white and light gray scales, and the most recent ones in darker gray scales.

**Table 1.** Overview of the oil spill cases (ChartsBin, 2011; Encyclopaedia Britannica, 2018; Marine Insight, 2018; Mother Nature Network, 2010; The Telegraph, 2011).

| Cases | Location | Cause of spill | Millions of gallons | Year of the spill |
|---|---|---|---|---|
| BP's Deepwater Horizon | Gulf of Mexico | Well blowout | 210 | 2010 |
| Ixtoc 1 | Bay of Campeche off Ciudad del Carmen, Mexico | Well blowout | 140 | 1979 |
| Atlantic Empress | Off the cost of Trinidad and Tobago | Collision | 90 | 1979 |
| ABT summer | Off Angola coast | Fire and explosion | 80 | 1991 |
| Castillo de Bellver | Off Saldanha Bay, South Africa | Fire | 79 | 1983 |
| Amoco Cadiz | Brittany, France | Collision | 69 | 1978 |
| MT Haven | Mediterranean Sea, near Genoa, Italy | Explosion | 45 | 1991 |
| Odyssey | Off coast of Nova Scotia Canada | Heavy weather/fire | 43 | 1988 |
| Sea Stair | Gulf of Oman | Collision | 40 | 1972 |
| Torrey Canyon | Isles of Scilly, England | Navigation error | 35 | 1967 |
| Exxon Valdez | Prince William Sound, Alaska | Human error/collision | 11 | 1989 |

The case study search highlighted the limitations of the data collection mode. The same technique for gathering data was impossible for all cases for many reasons. These included the location of the spills, where limited information was available on the South Africa and the Caribbean cases. This contrasted with cases where much more detailed information was available and the language of publications was English, such as the United States cases. Therefore, various search methods had to be employed to identify relevant information. One was to use the United States Environmental Protection Agency (EPA)[2] database. It stored many cases reports, generally titled by the name of the case with the subtitle A report to the president. Another approach was to use academic databases such as EBSCOhost, ProQuest, and the Web of Science. Google search was additionally used to identify news about the events, in addition to the snowball strategy (Cook et al., 2019; Palinkas et al., 2015), where references from reports and papers were used to identify other relevant publications. When considering the limitations of this study, we would like to emphasize that the adopted case study approach relies more heavily on recent examples of marine-related oil spills, as there is limited data availability and reporting on earlier cases, and thus they correspondingly receive relatively less focus in this paper. It can, therefore, not be stated that data saturation was reached for the older cases. It should, nevertheless, be highlighted that when particular issues had been identified in several cases such as "clean-up cost/cost of habitat restoration" or "loss of lives, injuries, stress-related impacts on survivors", it was not considered of relevance to invest a great deal of time to find the same issues, for instance in the oldest cases, where limited information were available. In other cases, particular issues were only found in a particular case, for instance "separated families and alcoholism", despite a search for the same issues and the title of other cases studied. In these cases, saturation was considered to have been reached.

### 3.2 Data gathering and analysis

Various databases, such as EBSCOhost and the United States Environmental Protection Agency (EPA) database, were scrutinized to find relevant documents relating to each case study. The title of each case plus oil spill, e.g. "Exxon Valdez oil spill", was used as a search theme, then more specifically these themes were used in a combined search with concepts such as "report", "impact", "loss", etc. Then an Excel spreadsheet was used to track themes applicable to each case, and information was then synthesized (see Fig. 5) and presented in the findings section. The purpose was not to compare or

[2] https://nepis.epa.gov.

contrast cases, but rather to deduce the possible impacts pertaining to worst-case scenarios when a systemic risk of marine-related oil spills materializes.

## 4. Findings

Fig. 5 presents a holistic depiction of the worst-case scenario when a systemic risk of marine-related oil spills materializes. Information has been drawn from the cases studied and summarized in the figure. Impacts have been categorized as social/cultural, environmental, economic, security/policy and business-related, with each a contributor to the systemic risk. One should note that some issues might fall under more than one category. For instance, contamination of food sources, and consequently food security, might be discussed both under environmental and social/cultural impacts. To limit the length of the discussion each topic is only covered once, except the issue of legal proceedings since stakeholders may vary based on whose interests are being discussed. Each of the five categories shown in Fig. 5 are then analyzed in further detail, with sections 4.1 to 4.5 following the structure of analysis set out in Fig. 5, which breaks the consequences of oil spills down into their respective components: sociocultural; environmental; economic; security/policy; and business/partners. Then their specifics linked to the Arctic and insurance are evaluated in sections 4.6 and 4.7.

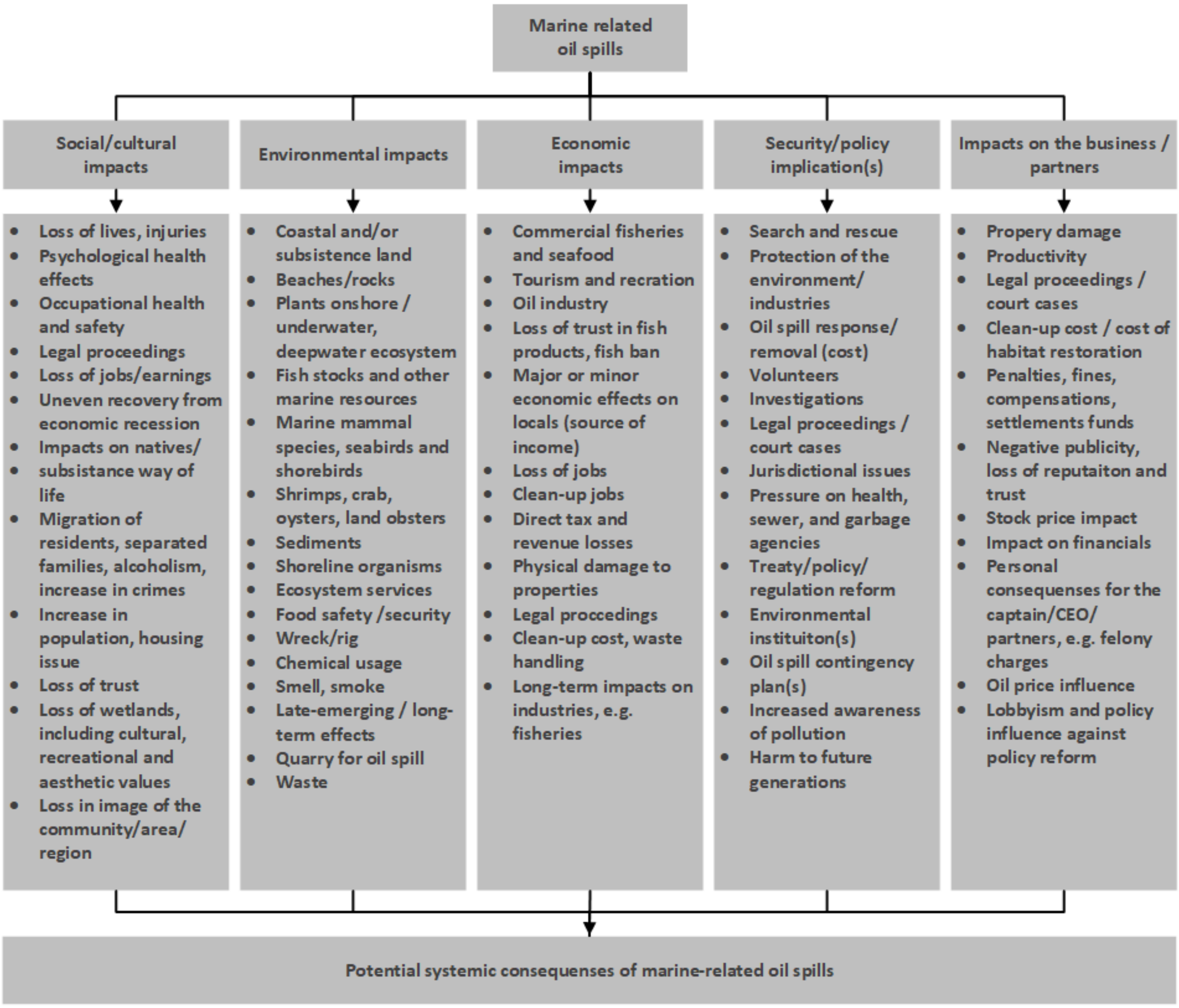


**Fig. 5.** Potential systematic consequences of marine-related oil spills synthesized by the authors.

### 4.1 Social-cultural impacts

In some oil spill cases there were losses of human lives and/or injuries (Deepwater Horizon Study Group, 2011). In other cases, such tragedies did not occur (ERCO/Energy Resource Co. Inc., 1982) or information about injuries or deaths were not easily found. Loss of employment, livelihood and earnings of locals are reported in some cases and migration of unemployed oilfield workers, while in some other cases there is a temporary increase in income of those taking part in clean-up activities (National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling, 2011). A spill may also have a stress-related impact on survivors, or physical or psychological health effects on survivors, locals and/or children including post-traumatic stress, anxiety or depression, particularly in relation to clean-up activities or loss of economic status. Such consequences are mainly discussed in the case of Exxon Valdez (Palinkas, Russell, Downs, & Petterson, 1992; Skinner & Reilly, 1989) and Deepwater Horizon (National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling, 2011). The consequences for affected individuals may include an increase in alcoholism, suicides, family violence, or separation of families (Mambra, 2018; National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling, 2011; The Sydney Morning Herald, 2010).

Cleaning activities may put a constraint on local communities, especially small communities, due to temporary, but massive, increases in population during clean-up activities (Taylor, 2014). This may put constraints on the “economic, political, and social infrastructure”, and in the case of the Exxon Valdez oil spill “housing quantities became inadequate, social service organizations were put under immense pressure, crime rates spiraled, and the health, sewer, and garbage agencies could not keep up with the massive scaling” of activities (Green et al., 2016). To address some of the housing issues vessels were used as floating hotels for oil spill workers (Taylor, 2014).

Concerns over occupational and health issues are also evident in connection with those taking part in clean-up and exposed residents (Laborers' National Health and Safety Fund, 1989; Skinner & Reilly, 1989). Consequently, there is a need for long-term health surveillance and longitudinal studies after a large scale oil spill event occurs (Lichtveld et al., 2016; Skinner & Reilly, 1989). Furthermore, there may be loss of cultural, aesthetic, and recreational uses of beaches or wetlands (Bonnieux & Rainelli, 1993; National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling, 2011).

Civil class action lawsuits are likely in case of oil spills, but they can drag on for years or even decades such as in the case of the Exxon Valdez disaster (Lieff Cabraser Heimann & Bernstein LLP, 2006; National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling, 2011). This may cause a “shift in the source of disruption and stress from the spill to the litigation” (Picou & Martin, 2007, p. 38). In addition, there may be a loss in trust (Shaw, 1992) on a broad scale, stemming from those causing the disaster or the industry (Ebinger, 2016), food safety and security (Fall, 1991; Skinner & Reilly, 1989), and loss in image of the local community and the tourist area or the region (Barkham, 2010; Nadeau, Kaplan, Sands, Moore, & Goodhue, 2014).

### 4.2 Environmental impacts

Oil spill disasters will often have vast negative environmental impacts. They may cause a loss of coastal areas and/or subsidence of land (Fall, 1991; Skinner & Reilly, 1989), contamination of beaches and rocks (Deepwater Horizon Study Group, 2011; The Guardian, 2017b; Wells, 2016), negative impacts on wildlife, including the killing of mammals, fish stocks, seabirds and shorebirds and various marine resources (Adams, 2015; ITOPF, 2018; National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling, 2011). Loss of land may also be due to the handling of contaminated waste, or by setting up a quarry on land to store oil from beaches (The Guardian, 2017b). Such quarries may cause risks to wildlife, especially birds that may mistakenly identify it as a water source (Deutsche Welle, 2017). Shallow water sediments may become contaminated (Adams, 2015; Wells, 2016), as well as coastal vegetation, which may accelerate rates of erosion, wetlands may be lost (Lichtveld et al., 2016), in addition to damage to "deep-sea coral communities" and "seaweed habitats harboring deep-sea shrimp, crab, and lobsters" (Adams, 2015, p. 2). Unpleasant oil smells and/or smoke from a fire are also likely consequences of oil spills (CornwallLive, 2018; Jamieson, 2017).

Environmental impacts of rigs or hulls may differ greatly depending on whether or not they can be towed ashore and dissembled in an environmentally sound manner. They may sink into the ocean, or wash-up onshore. To prevent the wreck of Torrey Canyon from washing up ashore, which would have caused considerable environmental harm, a decision was made to bomb and sink the tanker, even using napalm in the bombing (Wilson, 1973). Chemical usage (dispersants) during the clean-up phase may cause negative environmental impacts (Wells, 2016), but there are also positive effects, such as decreased amounts of toxic gases inhaled by clean-up participants (Gulf of Mexico Research Initiative, 2013). However, less is being said in the literature about the long-term effects of such chemical usage on organisms and the marine environment. Negative impacts on natives and subsistence ways of life may also occur (Fall, 1991) deriving from negative impacts on wildlife and marine resources. Food safety and security may therefore become an issue (Skinner & Reilly, 1989), due to resource contamination and reduced opportunities to source produce. After the Exxon Valdez oil spill, harvesting equipment was used in the clean-up, limiting time for fishing, hunting and gathering activities (Fall, 1991). Monitoring of late-emerging effects and long-term impacts on ecosystems needs to be carried out, although it was previously assumed "that impacts to populations derive almost exclusively from acute mortality". However, in the case of the Exxon Valdez oil spill, the impacts on "the Alaskan coastal ecosystem, unexpected persistence of toxic subsurface oil and chronic exposures, even at sub-lethal levels, have continued to affect wildlife" (Peterson et al., 2003, p. 2082).

**4.3 Economic impacts**

While the impacts of oil spill disasters may be estimated shortly after the disaster "in terms of the costs associated with immediate and direct injuries to human lives, property, and productivity, the costs—short and long term—to the affected publics, their industries and commerce, and the environment cannot be accurately assessed" (Deepwater Horizon Study Group, 2011, p. 8), it may take years or decades for the impacts to fully realize (Lieff Cabraser Heimann & Bernstein LLP, 2006; National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling, 2011). The Amoco Caldiz case revealed difficulties "in evaluating natural damages costs since these costs are highly dependent on the assumptions made in order to calculate them, the models used and the scarcity of data available" (Bonnieux & Rainelli, 1993, p. 169). Systemic costs of oil spills have been categorized as pollution direct costs, which include direct clean-up costs and the costs of restoration, and other physical effects being tourism trade, amenities, and marine resources (Bonnieux & Rainelli, 1993).

The case of the BP Deepwater Horizon oil spill in the Gulf of Mexico demonstrates that individuals and businesses suffer economic losses, such as loss of jobs and earnings from recreation and tourism, commercial fisheries and marine-related resources (Adams, 2015), and the fish processing industry (Skinner & Reilly, 1989). One study on the BP Deepwater Horizon estimates the number of jobs lost during the period of 2010-2020 to be 22,000, corresponding to an $8.7 billion in economic loss (Sumaila et al., 2012). Meanwhile, the economic loss related to tourism was projected for the Gulf coastal area to amount to $22.7 billion for the period 2010-2013. These impacts last beyond the crisis resolution period, since there exist longer term impacts in terms of brand damage and tourist misperceptions (Oxford Economics, 2010). In the comparably sized case of Ixtoc Oil Spill (140 million gallons) it took three years for visitor spending to return to baseline pre-spill conditions, but in the case of the comparatively minor Exxon Valdez spill (11 million gallons) it took about two years (Oxford Economics, 2010).

In addition to damage to individuals and peoples' livelihoods (National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling, 2011) and businesses, there also exist negative economic damages to communities who need to be compensated for their loss (Adams, 2015). In addition, what may cause both short term and long term economic impacts is the perception of tourists about the safety of beaches, and consumers' beliefs concerning whether or not the ocean, fish products and seafood are contaminated (Gill, Picou, & Ritchie, 2012). Oil spills may therefore result in a decrease in tax revenue for communities affected by the spill, as well as an increase in investments in cleanup (Picou & Martin, 2007). Local economic impacts may last for a long time. In case of the Exxon Valdez oil spill the herring fishery was closed, with few exceptions, to commercial fishing for approximately two decades (Struck, 2009). To mitigate short term unemployment, companies have gone so far, in the case of Deepwater Horizon, to keep employees on their payroll instead of laying them off. In most cases the companies did this at their own loss, covering their costs with a significant amount of their savings (Greater New Orleans Inc., 2011). When layoffs occur, these may lead to minor or major economic effects on locals in terms of their income, the extent depending greatly on how long people are unemployed.

Although disaster waste may be collected and handled by contractors, such as was done in the case of Deepwater Horizon, where BP hired private contractors (Kubendran, 2011), it may be much more problematic to deal with in more remote areas, such as the Arctic. Paying for clean-up efforts is one aspect of oil spills, and the case of the Exxon Valdez involved an estimated clean-up cost of over $2 billion. The oil spills, however, have another aspect which is relatively high paid clean-up jobs, where locals and commercial fishermen from affected communities are hired, thus creating a new source of income and cash infusion into local communities for a limited period of time (Russell, Downs, Strick, & Galginaitis, 2001). Oil spills may also create revenues for property owners, such as hotel owners, although the rate charged might be lower than for other hotel guests (Butler & Sayre, 2012). In the case of Deepwater Horizon, BP established the Vessels of Opportunity program, a way for local fishermen to earn some income outside the formal claims process. Boats owned by locals were used as a part of the response effort, such as to transport supplies, and for booming and skimming (Department of Ecology, 2014). For these reasons there might be an uneven recovery from economic recession as some may be able to earn a living, especially in the short-term, while others may not be in a position to do so at all. These efforts, however, do not mitigate the other social, psychological, and cultural consequences of oil spills and cleanup activities (Russell et al., 2001). Properties, public and private, may be contaminated, thus having negative impacts on property owners such as a loss in value and even property use (McCallion, 2011). Physical damages to properties may include personal properties, piers, boardwalks or seawalls, such as in the case of Amoco Cadiz, and these properties might be damaged either from the oil itself or during the clean-up process involving the use of high-pressure hoses (National Ocean Service (NOAA), 1983).

Cleaning up oil spills will be costly, not just for those responsible for the spill, but there will also be strain on local and/or national resources. Cost estimation is based on many factors, including oil spill persistence toxicity, spill amount, location, logistics, resources available, political and liability compensation regimes, response regulations and more. It also depends on shoreline impacts, ranging from non or minimal oiling to major oiling, oil type persistence ranging from no-persistence to heavy fuels, and cleanup strategies, where manual recovery is much costlier than only using dispersants (Etkin, 1999). Local cleanup cost may include increased costs of emergency, fire and police services, public health costs, costs related to waste collection, transportation and disposal generated by the response and recovery efforts, communication costs and costs associated with managing volunteers (Stone, 2015).

For listed companies oil spill disasters will most likely have stock price impacts, thus with financial consequences for stockholders. BP's financial performance was significantly disrupted after the Deepwater Horizon spill, as well as the company's stock price. In the first few months after the disaster the common stock of the company "lost more than half its value with the stock's trading volume surge" (Chamberlin, 2014; Investopedia, 2018), meaning that stockholder wealth was being destroyed and they were trying to minimizing their loss by divesting from the company. Costly legal proceedings and court cases, already discussed in the paper, may also destroy financial values for stockholders. What may offset the costs the company/operator are faced with is a rise in oil prices after a disaster, such as was the case after the Deepwater Horizon spill (Vaughan, 2018).

### 4.4 Security / policy implications

Large oil spills may have both security and policy implications. These include actions that are immediate, as well as long-term and preventive actions. Immediate actions relate to emergency and security, in particular search and rescue operations for missing crew members of a tanker or an oil rig in order to saves lives (National Oceanic and Atmospheric Administration, n.d.). They may also be carried out to protect the local environment and economic interests and industries, for instance when authorities will do the utmost to protect local, regional or national interests such as was the case with the Royal Navy actions and bombing of the Torrey Canyon wreck (The Guardian, 2017b; Wilson, 1973). Of immediate importance is also how to deal with the oil spill and oil contaminated waste and strain placed on health, sewer, and garbage agencies (Green et al., 2016). In the case of the Torrey Canyon the reported cost incurred by the British and French government was over $US 16 million, and efforts to clean up the spill took months (Federal Court of Australia, 2017). There are also occupational health and safety concerns such as inhalation exposure, exposure to chemicals, long working hours, potential physical injury or hypothermia (Skinner & Reilly, 1989), although it may take a long time for some of the health effects to materialize, along with their associated health costs. In this context it is of value to recognize that clean-up respondents often include volunteers who do not possess health coverage, and others dealing with the consequences may include local fishermen, firefighters, municipal workers and even military/navy personnel.

Longer term actions include national/local governments investigations (Deepwater Horizon Study Group, 2011; Skinner & Reilly, 1989) and law suits against owner/operators of a tanker ("Oil pollution settlement," 1969) or a rig (National Oceanic and Atmospheric Administration, 2017) to cover for economic and environmental losses. This may, however, be problematic, in particular when spills affect both coastal and international waters, meaning that solving legal issues becomes a matter of jurisdiction (Federal Court of Australia, 2017). Reforming of rules, regulations and/or international treaties is quite evident in the case of oil spills (Federal Court of Australia, 2017; Federal Register, 2018; U.S. Department of the Interior, 2010), as well as the establishment of new institutions or office(s) (Bureau of Safety and Environmental Enforcement, n.d.). Revision of preparedness, national response systems, and contingency plans covering coordination, responsibility, exercises, training, equipment, clean-up methods, communication efforts and so on, may also occur, since these are of great importance as "a first line of defense" (Skinner & Reilly, 1989, pp. ES-1).

An issue of future security and potential societal costs is lobbyism by the oil industry. This was evident in the wake of the Deepwater Horizon oil spill where the American Petroleum Institute increased its lobbying spending from $US 1.3 million to $US 2.3 million in the months before and after the crisis in order to "influence Congress on a number of spill-related bills" related to liability and clean-up costs (Frates, 2010).

Oil slicks from spills may also raise environmental awareness, an evident feature of the Torrey Canyon incident in 1967 (Barkham, 2010). What is also seen as worrisome in terms of the natural environment are impacts on generation of species (Chang, Stone, Demes, & Piscitelli, 2014), and also on generations of locals reliant on the natural environment for their livelihoods (Louisiana Department of Wildlife and Fisheries, 2011).

**4.5 Impact on businesses, business partners and contractors**

When systemic failures occur, the consequences may extend beyond the main operator to business partners and/or contractors who "share risks and rewards" of the development (National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling, 2011, p. 40). For the operators/owners of the ship or the rig there will be negative consequences. These could be loss of lives, property damage or loss (PwC, 2014), direct clean-up costs, national, local and/or civil settlements, criminal fines and penalties, costs of habitat restoration and the establishment of settlement funds (National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling, 2011; National Oceanic and Atmospheric Administration, 2017). Property damage and/or loss may lead to loss in productivities and other consequences, not only for the property owner, but a network of business partners as well. In the Deepwater Horizon case BP was the project operator, Transocean was the offshore drilling operator and the owner and operator of the rig, Cameron provided blowout preventer equipment, and Halliburton was a service provider of cement used to stabilize the well's walls (MIT Sloan, n.d.). Property damage or loss may then lead to financial losses for the companies involved in or impacted by the disaster, as BP's partners and key contractors faced potential liability for damage to natural resources harmed by the oil spill in the wake of the disaster (National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling, 2011). Negative publicity, loss of reputation and trust is harder to quantify in terms of financial losses, but "an incident like the *Exxon Valdez* accident can crystalize public opinion against the petroleum industry almost instantaneously" (Skinner & Reilly, 1989, p. 30). This can be seen in the reaction on social media in terms of possible boycotting activities of BP's consumers, and a campaign against the company in the wake of the Deepwater Horizon spill (Rohrer, 2010).

There are also consequences for the company responsible for the spill. In the case of BP Deepwater Horizon, the cumulative pre-tax cost of the incident amounted to $65.8 billion, with most of this cost relating to litigation and claims costs ($41.7 billion), followed by spill response cost ($14.3 billion) and environmental costs ($8.5 billion) (BP, 2018) (Investopedia, 2018). Negative impacts on public image and reputation (Kaye, 2015) are also likely impacts resulting in a drop in revenue and financial losses (World Finance, 2016). In addition, there may be consequences for the energy industry as a whole, with abrupt losses in earnings when government agencies halt deep-water drilling after an oil spill, and such decisions can extend to moratoriums on the issuing of shallow water oil drilling permits for a period of time (Greater New Orleans Inc., 2011).

The outcome of court cases may depend on the specific regulatory framework in each country, but according to the US Oil Pollution Act of 1990 there is a strict liability for "removal costs and certain damages resulting from the spill", but a cap is imposed on liability damages, except in cases of "gross negligence, violation of applicable regulation, or act of war". It should be noted that damages may exceed the existing caps, and those causing the damage may not have sufficient financial clout to fully cover the damage (National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling, 2011, p. 245), ensuring that the burden of negative externalities is ultimately suffered by oil spill victims or taxpayers. For instance, in Australia, oil companies are able to claim tax reductions for cleanup costs, a form of indirect subsidy which transfers cleanup costs to taxpayers (The Guardian, 2017a). This suggests that the settling of litigation cases will not compensate fairly all those affected by oil spills (Russell et al., 2001). Litigation cases may be of a civil and criminal nature, and when the Federal district judge approved settlements of $US 20.8 billion, in the case of Deepwater Horizon, it was the largest environmental damage settlement in US history. The settlement was allocated to ecological, economic and coordination of restoration efforts, criminal penalties and research efforts. In addition, private claims were estimated in October 2016 to amount to $US 14.8 billion (National Oceanic and Atmospheric Administration, 2017).

There may also be personal consequences for the captain of the ship, the CEO of the company, management, supervisors or others. In the case of Deepwater Horizon the CEO of BP, Tony Hayward, had to leave the company due to pressure over how he handled the disaster (The Guardian, 2010). The same case lead to the filing of manslaughter charges against the supervisor responsible for safety on board the rig, albeit these charges were later dropped (NBC News, 2015). In the case of the Exxon Valdez criminal charges were filed against the captain of the ship, based on his intoxication, negligent discharge of oil and reckless endangerment (Berliner, 1989).

As a consequence of an oil spill the company may also face operational obstructions, such as temporary bans on supplying fuels to governmental clients, bans on bidding for new drilling projects (Chamberlin, 2014) or tighter environmental regulations in the wake of a disaster (PwC, 2014). As explained before, companies may therefore increase spending on lobbyism in order to minimize the negative impacts of possible policy reform, such as cases of liability or cleanup costs (Frates, 2010).

**4.6 The Arctic Context of oil spills**

Irrespective of the small population in the Arctic, the region is becoming increasingly important in an economic and geopolitical sense, given the potential of developing significant amounts of oil, gas, and mineral resources (Anisimov et al., 2007; Malinauskaite et al., 2019). In the Arctic an increase in economic activities, such as offshore energy production, will increase the risk of major pollution incidents such as oil spills, with potentially negative impacts on local food sources because of contaminants and toxic substances that accumulate in the food chain of animals consumed as traditional foods (AMAP, 2015). Significant spills may occur as a result of trans-Atlantic or destination shipping, or offshore energy developments (SINTEF, 2011). As a consequence of oil spill risks, the Arctic Council initiated a project, 'Emergency Prevention, Preparedness and Response' (EPPR), and published a subsequent technical report on circumpolar oil spill response (EPPR, 2017). The report discusses weather conditions in the Arctic, i.e. "effects of wind, waves effects of wind, waves, air temperature, wind chill, sea ice, superstructure icing, horizontal visibility, and daylight/darkness" on particular oil spill response systems (EPPR, 2017, p. iii)". These systems are 1) mechanical of vessels, ranging from 1-3 ships taking part in the recovery, 2) dispersants from the vessel, aircraft or a helicopter, or 3) in-situ burning techniques of vessels or helicopters. The Arctic Council's working groups and task forces, current and previous, are instrumental in initiating work that may reduce oil related risks in the region, as they are or have been focusing on issues such as telecommunication and connectivity, marine oil pollution prevention, preparedness and response, and search and rescue (Arctic Council, 2018c).

The scope of the prevention, preparedness and response study neither included systemic risks and impacts of oil spills, such as long-term environmental, human or social impacts nor a "comprehensive overview of Arctic oil spill response options or implementation (EPPR, 2017, p. 2)". Instead, another Arctic Council Working Group specifically focused on surveying community leaders and local emergency response officials on oil spill preparedness in small communities. The main outcome of the survey was a need for greater risk awareness and local level preparedness, as well as access to information about best practices, the role of national governments in addressing lack of awareness and misperception, and a gap in terms of preparedness corresponding to risks (Arctic Council, 2018b). Furthermore, a database including a response to self-assessment was created, as well as a spill response and recovery library. The findings, furthermore, suggested that "roughly 25% of small communities are prepared relative to risk; 50% of small communities are moderately prepared relative to risk; and 25% are less than adequately prepared relative to risk" (Arctic Council, 2018b, p. 6). It is highlighted that in order to address the economic development in the Arctic and the environmental change taking place, impacts will occur to indigenous ways of life and their traditional activities, but at the same time indigenous knowledge on the conservation and sustainable use of resources should be recognized and embedded in policy making (Arctic Council, 2016b). It is the "Arctic peoples [that] have the most to offer, and the most to lose, from any future scenario in the Arctic" (Stotts, 2010). Locals have criticized the capacity of the oil industry and the government to handle the oil spill in the Gulf of Mexico in 2010, however, oil spills in ice infested waters are even harder to deal with than events in open water, and Arctic waters "might never recover from an environmental catastrophe like the one in the Gulf of Mexico" (Stotts, 2010).

Liability in itself involves implications for oil and gas developments in the Arctic since international conventions or international agreements do not exist that "establishes a liability system for claims for compensation or the cost of cleaning up pollution for an offshore oil and gas incident either in the Arctic or anywhere else in the world" (WWF, 2015, p. 7). For this reason, liability legislation in each country would apply in the event of an oil spill, but the liability systems of the respective Arctic nations differ considerably. In four cases that have been studied (Canada, Demark/Greenland, Norway, United States), operators/licensees need to "provide evidence of financial security to carry out offshore oil and gas activities" and measures are defined in their licenses, but these could be bonds, insurance, self-insurance, guarantees from third parties such as a mother company or letters of credits, or membership in a pooled fund (WWF, 2015, p. 7),. Combinations of financial security instruments are also allowed. However, gaps in the liability systems of Arctic states have been identified, and it has been proposed that the Arctic Council should consider establishment of an Arctic offshore oil spill compensation fund which would align with the polluter pays principle (WWF, 2015). It should be noted that in some cases there is a strict liability, but in other cases there is an overall cap on claims payments and the scope of claims may either be limited or the scope of the coverage is unclear (Emmerson & Lahn, 2012; WWF, 2015). What complicates things further is the potential trans-national impact of oil spills, meaning it has to be established who is/are liable and under what liability regime. This is costly and it can take a long time to settle such disputes (Emmerson & Lahn, 2012). The agreement on Cooperation on Marine Oil Pollution Preparedness and Response in the Arctic does not solve these issues, and the only cost that is addressed in this agreement is the cost of assistance, i.e. from another vessel (Arctic Council, 2013).

Due to the following factors (I) geographical and biological characteristics of the region and Arctic weather and sea conditions (EPPR, 2017), (II) infrastructure limitations in the Arctic (Emmerson & Lahn, 2012; Skinner & Reilly, 1989), (III) mainly moderate (50%) or limited capability (25%), relative to risk, of small communities to deal with oil spill risks and consequences (Arctic Council, 2018b), the systematic consequences of oil spills might be worse in the Arctic that in many other places around the globe. The risk for Arctic ecosystems might be disproportionally high due to local conditions, and oil spills may be caused by factors such as "mechanical or structural failure, human error, acts of God, inadequate or inappropriate design [for Arctic conditions], and sabotage" (Skinner & Reilly, 1989, p. 1). Ecosystems, various species, and local communities may be especially vulnerable to the consequences and adversely affected (Anisimov et al., 2007). Indigenous peoples, and their traditional way of living, are at risk since Arctic sensitive ecosystems on sea and land are source of their nutrition, in addition to having economic, cultural and social values (AMAP, 2015; IPCC, 2018). For Arctic peoples, economic development should not jeopardize the natural environment, and in order to reach this goal three principles are emphasized; sound science, prudent management based on conservation, and a responsive public process (Arctic Council, 1999).

One issue worth mentioning in the Arctic context is that it may take time for oil spill control equipment to arrive at the scene (Skinner & Reilly, 1989), as well as for clean-up experts to arrive to deal with the disaster. The clean-up cost many therefore be significantly costlier in the Arctic than in less remote areas with more developed infrastructure. In addition, that managing of the cleanup may depend on geomorphology, weather conditions, actions of waves, tides, and various dispersants (Bonnieux & Rainelli, 1993).

**4.7 Insurance in the context of oil spills in the Arctic**

In a seminal report (2012), initiated by Lloyd's of London, on opportunities and risk in the Arctic, key industry sectors are discussed, including mining, oil and gas, fisheries, shipping and logistics, and tourism. Risk categories are identified as operational, regulatory, environmental and liability (Emmerson & Lahn, 2012). The study acknowledges that there may be opposing interests in economic development, and that several companies may be involved in cases of pollution, making it hard to allocate liability, but the discussion about the social and cultural aspects of the development are more or less missing. The same gap applies to a Lloyd's report on the challenges and implications of drilling in extreme environments (Rees & Sharp, 2011), and a report recognizing that environmental systemic risk is of an increasing importance, with possible impacts for insurers who endeavor to deal with the risks of such an eventuality (PwC, 2014). Barriers to the embedding of environmental systemic risk in insurance mechanisms are lack of understanding, the limits of insurability, reactive pricing, uncertainty and lack of data, regulatory issues, and competitive pressure (PwC, 2014).

Limited discussion has occurred on the role of insurance in cases of oil spills, such as their role in loss prevention and claims settlement, although it has been brought up by the Lloyd's of London that the energy industry needs to "adopt standards that ensure safety and reliability in the design and execution of drilling in extreme environments", and insurers also need to "identify and monitor their accumulative exposure" to such risk (Rees & Sharp, 2011, p. 6). Furthermore, in cases of oil rig loss, such as the BP Deepwater Horizon, types of relevant insurance coverage include insurance against physical damage or loss of equipment and property owned by the company and/or operator, coverage during and after the construction of a project, business interruption/loss of production income, operator's extra expenses when they need to regain control over the well, liability, including comprehensive general liability, workers compensation/employer's liability in case of injuries or death, and environmental/pollution liability (Hartwig, 2010).

Insurers have multiple roles, including product and service offering, underwriting and risk management, loss prevention and claims settlement, and investments (Johannsdottir & McInerney, 2018; Johannsdottir & Wallace, 2019a). They can bridge the gap between heterogeneous stakeholders (Johannsdottir & Wallace, 2019a), and can also, as institutional investors, influence companies behavior and market trends, such as "to insist that environmental considerations are incorporated into overall strategic and resilience planning". Insurers can talk to governments and regulators, collaborate with other insurers and reinsurers, build close relations with providers of information, engaging more with customers, and participate in industry initiatives (PwC, 2014). On an individual company level, insurers can develop mandates from their boards for identifying environmental systemic risk (both financial and non-financial), review their investment portfolios, identify competitive advantage opportunities, review their underwriting guidelines so that they take into account environmental systemic risks, identify data and carry out research, and strengthen the skills of their employees, and provide information, tools and training, so that employees are in position to deal with such types of risk (PwC, 2014). Moreover, general principles of risk assessment may be employed, which are to 1) assess risks relative to objectives, or interests (what should be avoided and what is the likelihood), 2) assess what are the biggest risks (worst-case scenarios), 3) consider the full range of probabilities (low probability might result in high risk), 4) use the best available information (could be science, expert judgement – or in the case of the Arctic, include indigenous knowledge), 5) take a holistic view, including systemic risk and direct risk, and 5) be explicit about value judgements (King et al., 2015).

The insurance sector has highlighted the importance of public understanding of risk since there is an inconsistency between perceived and actual risk, and that increased understanding will improve the quality of decisions made by individuals, businesses and policymakers (Lloyd's Register Foundation, 2017). A part of this understanding would be to bring forth information about the extent of financial losses, in case of oil spills, that were absorbed by insurance companies but this type of information is very challenging to find. Nevertheless, it is important to bring forth information regarding terms and conditions under which Arctic shipping and energy projects are covered, so that possible gaps in coverage in cases of worst-case scenarios may be identified. In scenarios of maritime casualties, costs are generally absorbed by a complicated system of insurance underwriting and protection and indemnity clubs (Harrald, Marcus, & Wallace, 1990). Less is known about other types of consequences, or insurance terms and conditions such as for Arctic shipping (Sarrabezoles, Lasserre, & Hagouagn'rin, 2016) or energy development/operation projects, as this information is seldom disclosed by insurance companies, although it is known that insurance companies impose stricter requirements and higher premiums on Arctic shipping contracts than for other shipping contracts (Sarrabezoles et al., 2016).

The insurance sector plays an instrumental role in enhancing best practice, relating to energy developments in the Arctic and Arctic shipping practice, and the sector made a contribution to the development of the Polar Code, since there is a "risk-based approach in determining scope and to adopt a holistic approach in mitigating all risks to acceptable levels" (Arctic Portal, 2016). The International Union of Marine Insurance supported the development of the Arctic Marine Best Practice Declaration (Backman, Rohlén, & Kingston, 2013), an initiative that fosters "common ice regime guidelines in the Arctic that would support the Polar Code and improve safety standards", and POLARIS (Polar Operational Limit Assessment Risk Indexing System), a regime system (Arctic Portal, 2016). The Nordic Association of Marine Insurers (Cefor) has developed a checklist for underwriters and owners/managers for assessing risks associated with voyages in Arctic waters with the purpose of heightening their awareness of risks associated with such journeys. The list covers accident scenarios of different nature, but it highlights infrastructure limitations in the region and limited search and rescue resources, stating that "minor casualty can become extremely costly" due to the remoteness of the Arctic location (The Nordic Association of Marine Insurers (Cefor), 2012). To minimize risk, the checklist advocates addressing the necessary documentation to comply with national regulations, focus on the suitability of the vessel, logistical and meteorological preparedness, and ensure crew competence in order to fulfil contractual duties and the respective responsibilities of all parties involved in the voyage (The Nordic Association of Marine Insurers (Cefor), 2012).

## 5. Discussion

### 5.1 Arctic and insurance implications

Politically influential strategy documents (Wilson Center 2014; Emmerson and Lahn 2012a; Foreign and Commonwealth Office 2013) tend to keep social/cultural and ecological dimensions comparatively separate, although some call for much more engaged and integrated approaches to Arctic management (Clement et al. 2013). Indeed, in recent times, the Arctic Council have called for ecosystem-based approaches to the management of environmental resources, a holistic approach integrative of economic, environmental and socio-cultural objectives, with the pursuit of human wellbeing and minimization of harms to it at its core (Arctic Council, 2013b; Malinauskaite et al., 2019). As far as the authors are aware, no studies have yet been carried out on the extent to which the management of Arctic resources accords with visions of ecosystem-based management, although the Arctic Council has deemed the approach of sufficient importance to establish an Expert Group on the topic, which is focused on developing the topic so that it becomes the overarching goal of the institution (Malinauskaite et al., 2019).

The insurance sector seems to have a role to play in terms of raising awareness about Arctic related business risks, among business leaders, policymakers, and individuals (Lloyd's Register Foundation, 2017), and an instrumental role in enhancing best practice, both in cases of energy developments and shipping practice (Arctic Portal, 2016; The Nordic Association of Marine Insurers (Cefor), 2012). This may be recognized as a loss prevention initiative of insurers. Risks may also be minimized if systemic risks are identified and relevant systemic crisis management strategies emphasized and implemented, taking into account exercise, training, equipment, financial aspect, prevention, logistics, infrastructure, clean-up methods, communication, and contingency plans and response system(s). Moreover, there is increasing evidence that the insurance industry is concerned, with a "series of major financial institutions to raise a red flag about investment in Arctic oil operations over concerns about climate change and environmental risks" (Arctic Today, 2019). Equally, observant of such worries, it is expected that stakeholders will gradually expect insurers to consider environmental systemic risks given the wide impacts these losses can have (PwC, 2014). Despite the importance of systemic risk, HROs, and megaprojects for Arctic economic development, limited information about this subject is available on the Arctic Council's website. However, much greater information exists on oil spills, and it is evident that increased oil and gas exploration, as well as shipping, are growing concerns, and that there is an emerging need for knowledge on these topics (Arctic Council, n.d.). Additionally, more can be done to prevent oil spills in Arctic waters and to enhance adequate response capacity to spills across the Arctic (PAME, 2011). Increased traffic in the Arctic is expected to increase the likelihood of incidents, in turn increasing risk. In relation to oil and gas activities, collaboration is needed, including the engagement of indigenous peoples, risk assessment/analysis, and emergency preparedness and response (Arctic Council, 2016c), as this approach may minimize risks and help resolve potential conflicts between the often competing interests of fisheries, local community subsistence livelihoods, and the oil and gas industry (ARAF Chair, 2016; Arctic Council, 2016b).

Insurance has been identified in licenses as a suite of financial security approaches used to cover risky offshore oil and gas activities, the others being bonds, self-insurance, guarantees from third parties, or membership of a pooled fund (WWF, 2015). Self-insurance is, however, unfeasible in most cases, with only the largest companies in position to deal financially with major accidents (National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling, 2011). Limited information is available regarding insurance coverage in licenses, terms and conditions, or, in cases of oil spill disasters, the proportion of financial losses absorbed by insurance companies. This is nevertheless of importance, since encouraging responsible risk-management can be highlighted through the insurance premium (National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling, 2011) and conditions. Knowledge gaps related to coverage in worst-case scenarios is evident, except that insurance premiums increased by up to 50 percent for deep-water operations in the wake of the Deepwater Horizon spill, and there was a potential risk of elimination or raising of the liability cap through legislative efforts so that social costs may be covered (National Commission on the BP

Deepwater Horizon Oil Spill and Offshore Drilling, 2011). Such reform of legislation may cause insurance companies to shy away from offering oil pollution coverage, since social costs may be unpredictable or too costly. If liability limits are raised, it is expected that new safety methods and techniques will be promoted/insisted by insurers and risks monitored (National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling, 2011). Barriers within the insurance sector are also recognized, including limits of insurability, reactive pricing, uncertainty and lack of data, regulatory barriers, and competitive pressures (PwC, 2014).

**5.2 General reflections on systemic risk and marine-related oil spills**

The first part of the paper defined systemic risk – although there is no universal definition existing, a trigger event or tipping point is emphasized. An institutional failure or economic shock could cause "a chain of bad economic consequences - sometimes referred to as a domino effect (Schwarcz, 2008, p. 198)". This depiction, however, highlighted that systemic risk is quite often discussed or defined in the context of financial systems of market price volatility (Schwarcz, 2008), or structural flaws. Viewing systemic risk solely as a risk to a financial system may be considered too limited, and instead systems to be considered should include environmental, social, financial, and technological dimensions (Baue, 2017; Burckart et al., 2016; King et al., 2015; Lloyd's Register Foundation, 2017), all of which are highly interconnected (Lloyd's Register Foundation, 2017). This is already recognized by the insurance sector, which has identified the characteristics of systemic risks (PwC, 2014). In order to protect a whole system from a systemic risk, regulation is needed to internalize or prevent the risk from materializing, otherwise the cost will be externalized (Goldin & Vogel, 2010; Humphreys & Thompson, 2014). Regulatory cost should, however, not exceed its benefits (Schwarcz, 2008). The analysis in this paper also shows that the risk focus is usually on enterprise level risks or risks in investment portfolios, although investors are starting to recognize systemic risks, and to a lesser extent existential risk (Thurm et al., 2018). The Polar Code has the potential to mitigate some of the risks of sailing in polar waters, but it has its limitations (Fedi et al., 2018), one being a decided focus on enterprise level risks.

High reliable organizations (HROs) need to be recognized as well (Deepwater Horizon Study Group, 2011; Roberts & Bea, 2001), since these organizations will run complicated systems (Roberts & Bea, 2001) that may fail. Megaprojects, such as infrastructure projects, offshore oil and gas extraction or large container or cruise ships, are highly relevant to considerations of systemic risk and its likelihood.

The second aspect of the paper used a broad case study approach, not limited to the Arctic, to highlight the potential systematic consequences of oil spills in marine environments. Five impact categories were identified and their consequences discussed in turn. The categories were 1) social/cultural, 2) environmental, 3) economic, 4) security/policy, and 5) businesses and their partners. Through this analysis, it is evident that the most detailed information exists on the most recent cases of oil spills or cases with comparatively vast impacts, including the Deepwater Horizon (Deepwater Horizon Study Group, 2011; National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling, 2011), and the Exxon Valdez cases (Emmerson & Lahn, 2012; Rees & Sharp, 2011).

Even in the most recent case analyzed, Deepwater Horizon, "energy exploration and production, particularly at the frontiers of experience, involve risks for which neither industry nor government has been adequately prepared, but for which they can and must be prepared in the future (National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling, 2011, p. vii)". The Deepwater Horizon case, in the third part of the paper, highlighted how regulatory oversight is not sufficient in itself, so the hydrocarbon industry needs to increase safety throughout the sector, such as by implementing self-guiding mechanisms. Furthermore, it is also claimed that limited scientific understanding of environmental circumstances, and the natural and human impacts of oil spills in sensitive environments, including the Arctic, is insufficient (National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling, 2011).

The fourth, and the last, aspect of the paper considered the role of insurance in eventualities of major marine-related oil spills. From the analysis, it is evident that the insurance sector is already recognizing the characteristics of systemic risks (PwC, 2014) and that environmental systemic risk is of an increasing importance (PwC, 2014), as well as the various opportunities and risks of economic development in the Arctic (Emmerson & Lahn, 2012), and the challenges and implications of drilling in extreme environments (Rees & Sharp, 2011). Four risk categories or Arctic-related risks are recognized: environmental, operational, regulatory, and liability (Emmerson & Lahn, 2012). Comparing these categories with the systemic risks identified in Figure 6, it is clear that social/cultural impacts are not addressed and perhaps security implications. To a limited extent, environmental and economic impacts are discussed, as well as impacts on business and policy (regulatory) standards. Additionally, a new issue in terms of oil spill impacts is the impact of social media discussion (Starbird et al., 2015) which companies need to plan for in case such events unfold. Negative social media debate may constitute an intangible risk related to a company's brand image and a financial risk if it leads to the boycotting of their products and services.

## 6. Conclusion

Developments in the Arctic are inherently risky. In recent times, considerable emphasis has been placed on opportunities to develop the Arctic's untapped hydrocarbon resources and expand trans-national shipping activities, in part due to the global scarcity of fossil fuels but also because of the emerging accessibility of resources and routes, events driven by climate change. This paper has highlighted how risks in relation to marine oil spills tend to be thought of in isolation, with an emphasis on managing, through the instrument of insurance, their enterprise aspects, as opposed to the systemic consequences. Using a case study approach, both in general and specific to the Arctic, this paper outlined the core implications of major marine-related oil spills, which have a multitude of impacts across several dimensions, including social and cultural, environmental, economic, security and policy, and business and partners. These, combined, can lead to systemic risk consequences, whereby a marine-related oil spill could precipitate, or act as a tipping point for, the severe instability or collapse of an industry. This risk is all the more acute in the Arctic, as the cited Exxon Valdez case study illustrated, and is reinforced by the challenges faced by shipping companies and hydrocarbon explorers in securing insurance to operate in Arctic waters.

Recent legal agreements, such as the Polar Code, have made a contribution to ensuring the safety of shipping in the Arctic, however, considerable risks remain relating to the remoteness of the region, extreme weather events, and limited availability of search and rescue services. Given these factors and the potential impacts to the 4 million inhabitants of the Arctic, many of whom are indigenous and rely on subsistence lifestyles, it is apparent that the potential for systemic risk events has been largely overlooked in the debate about how Arctic resources are managed and the deployment of appropriate insurance tools to manage risk. In recent times, the Arctic Council has begun to emphasize the importance of managing the region's pristine ecosystems in a more holistic manner, especially through the approach of ecosystem-based management. This approach places the importance of environmental sustainability as a primary objective alongside the maintenance of human wellbeing across the Arctic. Although yet to be assessed or implemented in a practical context, the approach has considerable potential for ensuring the sustainability of marine environments in the Arctic, and thereby minimizing risk. It was in the spirit of ecosystem-based management that this paper proposed two new frameworks, where subsistence and market economy activities were placed in an institutional and environmental context. This has relevance with regards to the management of systemic risks, but also shows the interplay between the subsistence and market economy activities, where conflicting interests may arise related to the utilization of hydrocarbon resources in the region. Given this, meaningful engagement of indigenous peoples and other inhabitants in the management of Arctic resources is of critical importance, since systemic risk may ultimately result in existential risk (in case of oil related disasters) for those on the subsistence level of the pyramid. Equally, the insurance industry has an important role when rules and regulations in the Arctic are formulated and further refined, including the raising of awareness and endeavoring to embed insurance terms and conditions in decision-making protocols.

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