Offshore Oil & Gas Installations in the Arctic: Responding to Uncertainty through Science and Law

Elizabeth A. Kirk & Raeanne G. Miller

The Arctic Ocean's physical environments and ecosystems are some of the most fragile and least well understood on Earth. They are characterised by extreme light and dark cycles, shortened food chains, and slow ecosystem recovery from disturbance. The Arctic seabed also holds promise of lucrative oil and gas resources, whose future exploitation could have substantial environmental impacts. Arctic jurisdictions must weigh environmental conservation and global agreements to reduce carbon emissions against the social implications and potential economic gain of offshore oil and gas projects in the Arctic, and must do so in the face of substantial scientific uncertainty around the impacts of climate and environmental change in the Arctic. We know, however, that major projects such as oil and gas projects have the potential to lead to transboundary environmental harm. We have some understanding of how any pollution may be carried by sea ice or on the ocean currents which flow around the Arctic Ocean. Even so, we have little understanding of how such pollutants might affect the Arctic ecosystem. Substantial gaps remain in scientific understanding of Arctic ecosystem functioning, particularly as it changes rapidly with the advent of climate change. These gaps in scientific understanding raise legal questions about how, for example, the law's obligation not to cause significant transboundary environmental harm applies in the Arctic. In particular one may ask what actions are required by a state to show that they have acted with due diligence. Is it sufficient, for example, to show that they have complied with existing international treaties?

This paper draws out key legal and scientific issues on which greater understanding is required. In essence it presents a roadmap for further research and negotiation.

Introduction

Some of the largest remaining petroleum reserves worldwide are located in the Arctic. Since exploratory drilling began in the 1970's there has been consistent interest in exploiting these resources (AMAP, 2007), although to date few fields have entered into production, owing to: low oil prices; the technological and logistical challenges of operating in extremely cold and remote environments; national commitments to climate agreements; and the risk of environmental impact that could result from a large oil spill or other serious event (Gulas et al., 2017). Even so, Norway has been active in offshore petroleum exploration in the Arctic since the Snøhvit field was

Elizabeth A. Kirk is Professor of International Environmetnal Law at Nottingham Trent University. Raeanne G. Miller is Post-Doctoral Research Associate in Marine Energy at the University of the Highlands and Islands.

discovered in 1984 (Norwegian Petroleum Directorate, 2018) and there is potential for further activity.

Should offshore oil and gas activity increase in the Arctic, so does the risk of harm to the marine environment. AMAP (2010) highlighted a number of key risks to the Arctic environment associated with oil and gas extraction, including: spills of hydrocarbons and other pollutants from offshore drilling activities, blowouts, rig accidents and shipping disasters; operational pollution from exploratory drilling; increasing volumes of rubbish and sewage; an influx of people to the Arctic; increased air pollution; noise pollution to the marine environment; increased emissions from burning fossil fuels; light pollution; and cumulative impacts stemming from multiple installations and human activities. Of these, this paper will focus on certain impacts directly associated with offshore oil and gas development: hydrocarbon spills, pollutants, underwater noise pollution, and the impact of cumulative development. While the remaining effects are important, they are also associated with wider human activity in the Arctic (mining, tourism, shipping, etc.) and so draw in broader considerations we do not have space to address here.

The Arctic Ocean itself is a remote and challenging environment, but also one which is inherently vulnerable to environmental change, and about which we know very little. Of the eight Arctic nations, five have exclusive economic zones within the Arctic circle (Canada, USA, Russia, Denmark, Norway). For the purposes of this paper, we consider 'the Arctic' to be the region defined by the Arctic Circle. More specifically, this includes the Arctic Ocean, as defined by the ocean north of the latitude 66˚34', and the states whose coastlines border it. This definition is environmentally relevant, as it includes not only areas of sea ice cover, but also the 'subarctic marine' regions between Norway and Greenland, through which most of the water entering and exiting the Arctic Ocean flows (Jones, 2001). This boundary is also politically relevant: the five aforementioned states have indicated their intention to collaborate, as communicated in the Ilulissat Declaration of 2008, and as illustrated in more recent agreements such as the 2017 moratorium on fisheries activity in the central Arctic Ocean.

Although separate in legal terms, the territorial waters of each nation bordering the Arctic are linked by ocean circulation, sea ice drift, and species migration, all of which can transport resources and impacts such as pollutants between them. It is an inherently connected environment. These characteristics mean that, for example, the risk of harm being caused to other states or to the environment beyond national jurisdiction may be higher in the Arctic than elsewhere even where pollution would normally be regarded as small scale. Similarly, recent advances in oceanography suggest that in some cases (e.g. pollutant spills in ice, Blanken et al., 2017) it may be possible to demonstrate causation linking operational pollution to significant transboundary harm.

Thus we highlight key legal and scientific questions that are linked to the specific impacts noted above and draw out how these impacts and the legal and scientific questions attached to them may differ in the Arctic to other oceans. The main discussion is focused upon what may be termed "flaws" in the legal framework and draws out the legal and scientific questions that need addressing. It thus sets an agenda for research in relation to offshore installations in the Arctic.

Flaws in the Framework and New Questions

The Potential for Significant Transboundary Harm

Coastal states have sovereignty over their terrirorial waters and sovereign rights to the hydrocarbon and mineral desposits in their continental shelf and to exploit renewable energy in their exclusive economic zones (UN Convention on the Law of the Sea 1982 (UNCLOS), Articles 2, 56 and 77). These rights underpin the exploitation of oil, gas and renewable energy sources in the oceans. While the rights give states considerable freedom to exploit resources, they do bring with them obligations. These obligations largely reiterate and expand upon customary international law obligations to protect and prevent harm to the marine environment, (Article 192) to prevent transboundary harm (Article 194(2)) and to harmonize their measures to prevent and reduce marine environmental harm (Article 194(1)). In addition, specific obligations to control pollution from offshore installations and to enforce those obligations are found in Articles 208, 210, 215 and 216. Obligations to control pollution from shipping found in Articles 211 and 217 to 221 are also relevant where ships are used to service and support offshore energy activities.

To meet these obligations in the context of potential transboundary harm states must apply the prevention principle (Advisory Opinion on Legality of the Threat or Use of Nuclear Weapons (ICJ 1996)). The prevention principle requires states to prevent "*significant*" transboundary harm and to do so by acting with due diligence. The problem with these obligations in the context of potential oil and gas activities in the Arctic is that what is meant by "significant" is not clear, nor is it clear what acting with due diligence requires.

What is regarded as significant has to be decided in the context of the particular issue. We know that "significant" means more than simply the harm is detectable, and that it need not require the harm to be substantial in nature. But in the context of the Arctic Ocean, where a relatively minor oil spill may linger longer than in temperate waters (Leahy & Colwell, 1990; Atlas et al., 1978), causing lasting damage to the environment, we have yet to fully understand what scale of pollution would count as significant. Would, for example, operational pollution which may accumulate across time amount to significant pollution? Some authors have suggested that incremental accumulation of impacts may not be captured by the term "significant harm" and so would not give rise to potential liability (Duvic-Paoli & Viñuales, 2015). Yet in the context of the Arctic a failure to address operational pollution could have significant (but unforeseen) impacts.

Although there is a substantial amount of information available on the environmental effects of hydrocarbons in the marine environment, relatively few impact studies have been carried out on truly Arctic species (but see Rice et al., 1978). Instead, the majority of research investigating the impacts of oil spills on marine species have focused on temperate waters. It is therefore difficult to predict how well these findings might be applied to the Arctic environment (AMAP, 2010) and while, for example, the Arctic Council takes a leading role in promoting the development of scientific understanding on these and other Arctic issues, significant gaps in understanding remain. With this in mind, existing international agreements on pollution and the marine environment (e.g. UNCLOS, OSPAR convention) may not fully encapsulate what is truly required to protect the Arctic Ocean.

The recovery rate of the Arctic marine environment in response to disturbance is likely to be slow, whether as a result of reduced species diversity, the slow-growing nature of many cold-water species, or the reproductive importance of the region for many species, for example nesting seabirds (Forsgren et al. 2009). Combined with the fact that Arctic food chains are comparatively short and dependent on key species (Kaiser et al., 2011), pollution, even comparatively low level operational pollution, could have severe impacts on the functioning of the Arctic ocean ecosystem. In addition, a number of factors could exacerbate the severity of an Arctic oil spill. At colder temperatures, for example, the density and viscosity of oil increases, while its degradation time is much slower (Leahy & Colwell, 1990; Atlas, 1981; Atlas et al. 1978). This means that spilled oil may linger on the seabed, under ice, or in coastal environments for longer than it otherwise would in temperate or tropical environments. In the case of the 1989 *Exxon Valdez* spill in Alaska, oil is still detectable in the intertidal environment. It has been suggested that oil trapped in sediment following the 1970 *Arrow* spill in Chedabucto Bay, Nova Scotia, Canada, could persist for as long as 150 years (Vandermeulen & Gordon, 1976). Each of these spills was, however, relatively contained in that the spill came from an oil tanker holding a relatively small volume of oil compared to what might emerge from a major spill at an offshore oil development. The risks of oil, or other chemicals, lingering in the Arctic environment as a result of an offshore accident attached to oil and gas activites are, therefore, significant.

In addition, in considering the impact of pollution in the Arctic we must consider the pollutant/ice interface and its impact on the marine ecosystem. The Arctic Ocean ecosystem is dominated by the seasonal fluctuation of sea ice. Sea ice is an important habitat for photosynthetic algae and sub-ice phytoplankton, the primary producers that form the basis of the Arctic marine food web (Post et al, 2013). Each year as the seasonal sea ice thins, increasing light penetration causes these primary producers to rapidly increase in numbers, in turn fueling the seasonal reproduction and growth of zooplankton such as copepods (Darnis et al., 2012, Gosselin et al., 1997), which serve as prey to higher order consumers including fish and crustaceans. While sea ice algae and sub ice phytoplankton are major contributors to biomass in polar seas, sea ice is also a critical habitat for many charismatic species such as polar bears, walruses, narwhals, and many species of seabirds, who depend on sea ice for reproduction, food, or migration (Hoegh-Gulberg & Bruno, 2010). Thus any impact on zooplankton as a result of pollution has a significant impact on the food chain. Pollutants such as oil may remain on the surface of the sea ice as it forms, or pool beneath it (Payne et al., 1990). Alternatively, sub-ice oil may also move upwards through the ice via brine channels (Petrich et al., 2013) and fissures in the ice, to ultimately appear on the sea ice surface (Lee et al., 2015). In so doing the oil or other pollutant may diminish light penetration or make the sub-ice areas no longer habitable. The short food chains and dependence of those food chains on ice may open the marine Arctic to more vulnerability to pollutants than would be the case in other ocean areas. Add to this the fact that 75% of sea ice volume has been lost since the 1980s (Schweiger et al. 2011, Overland and Want, 2013) and any further diminution of habitable ice area due to (even relatively low scale) pollution may have a severe impact on the Arctic marine ecosystem.

Clearly we are still to understand the extent of these potential impacts, but at the same time these potential impacts raise the possibility that states conducting or permitting offshore operations may be more likely to find themselves in breach of the obligation not to cause significant transboundary harm as a result of activities in the Arctic when similar activities elsewhere would not be predicted to cause significant transboundary harm.

There is a further aspect to this in that scientific evidence points to the possibility that the likelihood of transboundary impacts arising may also be greater in the Arctic than in other oceans because of the relationship (or potential relationship) between pollutants and ice. As we noted above, where released pollutants (e.g., oil, chemicals) interact with sea ice, they may become entrained within the ice in a number of ways, for example in association with the underside of the ice, transportation from the underside to the surface of the ice through brine channels or leads, or direct integration into sea ice formation (AMAP, 1998). Once a pollutant becomes ice-associated, it will often move with the ice as it is transported or dispersed by prevailing winds and currents (Afenyo et al., 2016; Beegle-Krause et al., 2013). It may then travel hundreds of kilometres as the ice moves, before it is released in another location (possibly another state's EEZ) as ice melts. For example, a recent study investigated the spreading trajectories of 'worst case scenario' oil spills in the Arctic, and found that the movement of sea ice had the potential to transport oil greater distances than ocean currents, sometimes over 4000 km, and that contamination from oil spills was in many cases likely to cross international boundaries (Blanken et al., 2017).

Again this raises both legal and scientific questions. Not only does it suggest that transboundary impacts may be more likely, but the relationship between pollutants and ice raises the possibility that causation will be easier to establish. In other words, it is possible that it will be easier to trace the flow of ice in the Arctic Ocean back to the state of origin of the pollution and this possibility may be enhanced by the relative paucity of development in the Arctic. Naturally these legal issues point to scientific questions that should be addressed – how do pollutants interact with ice? How far will such pollutants be transported? How easy is it to trace the pollutant back to source as a result of the pollutant/ice relationship?

States can mount a defense to any claim that they have failed to act with due diligence by showing, in effect, that they have acted reasonably. Due diligence, for example, requires that states take reasonable steps to avoid causing transboundary harm. The question of what is reasonable will be interpreted in light of any relevant international obligations and of the circumstances in which actions take place. Thus a state must show that it has acted in compliance with relevant international treaties or guidelines. Key obligations in this respect are those found in Articles 192 and 194 of UNCLOS which, as discussed above, oblige states to take action to protect and prevent harm to the marine environment and not to permit activities within their jurisdiction which will cause transboundary pollution. Other relevant agreements include global treaties, such as the London Dumping Convention 1972 and its 1996 Protocol which regulate dumping at sea (encompassing disposal of offshore installations at sea); regional treaties such as the OSPAR Convention 1992, Annex III of which in effect requires authorising states to regulate pollution from offshore installations and soft law instruments such as the Code for the Construction and Equipment of Mobile Offshore Drilling Units (IMO Resolution A.1023(26), 2 December 2009) which regulates the design of offshore drilling units to minimize the risk of harm to them or to those working on them. There is also a range of oil-based international treaties that apply to all areas, including the Arctic. These include the 1990 International Convention on Oil Pollution Preparedness, Response and Cooperation (OPRC) which requires, for example, operators to have an oil pollution emergency plan in place (Article 4) and states to have effective national pollution incident response systems in place (Article 6). The OPRC applies to any fixed or floating offshore structure engaged in gas or oil exploration, exploitation or production activities and so is highly relevant.

Compliance with these obligations is, in terms of due diligence, assessed in light of the circumstances. These may include factors such as the level of industrial development of the state and its geography. Thus, for example, a densely populated, territorially small state may be expected to have a very good awareness of the occurance of any oil spills on their land territory, whereas a more sparsly populated state with a large amount of land territory could not be expected to have such immediate knowledge. Such distinctions may of course diminish as remote sensing technology develops. In the Arctic context, however, what is key is that the environment is harsh and so responding to incidents may prove difficult. What might start as a minor (and in another location containable) spill, for example, could become a major incident before states are able to effectively respond. Crucially, none of the treaties or guidelines referred to above were developed for the Arctic specific environment and so a question arises as to whether states complying with these treaties, but still causing significant harm to the Arctic marine environment could be said to be exercising due diligence. In other words, do the specific environmental circumstances of the Arctic require the coastal states to behave at a higher standard than is required under the global treaties? The responses of some Arctic states suggest that may be the case.

A key response has been the adoption of some polar specific agreements and guidelines, notably those adopted under the auspices of or by the Arctic Council. These include the Arctic Council's Offshore Oil and Gas Guidelines 2009 (Arctic Guidelines) and the Arctic Offshore Oil and Gas Guidelines: Systems Safety Management and Safety Culture 2014. The Arctic Guidelines call, for example, for the application of the precautionary approach to oil and gas activities and set out guidance on the conduct of environmental impact assessments, monitoring, waste management and more. While at first glance the Guidelines appear comprehensive they do contain gaps. The precautionary approach is, for example, to be applied in accordance with the state's capabilities and how this caveat is to be interpreted is not made clear.

Potentially binding international law for responding to Arctic oil spills has also been adopted in the form of the Agreement on Cooperation on Marine Oil Pollution, Preparedness and Response in the Arctic (ACMOPPRA). However, although the Arctic states have signed this treaty, they have not completed all the steps necessary to bring it into force. A second agreement is the 2011 Agreement on Cooperation on Aeronautical and Maritime Search and Rescue in the Arctic, which came into force in January 2013. However, this Agreement focuses on protecting individuals at risk through accidents at sea in the Arctic, not on protecting the environment. These Arctic agreements are supported by the International Code for Ships Operating in Polar Waters (Polar Code), which contains various technical requirements designed to ensure the safety of ships (and those working on them) in polar regions.

While these agreements do go a long way to responding to oil spills, in our view compliance with them may not be sufficient to show that the state has acted with due diligence, nor may it be enough to prevent harm to the Arctic. This is largely because of the scientific information on which they are based. As we have shown above, significant questions about the impact of and transportation of pollutants remain. As we will show shortly, questions about the ability of the environment to recover from any pollution damage also arise. In addition, there is evidence of some Arctic states adopting further national Arctic specific measures so suggesting that higher standards yet may be required. For example, the US has adopted the binding Arctic Drilling Rules, which expressly cover exploratory drilling by mobile offshore drilling units and require a higher standard for drilling in the US Arctic than other areas of the US Outer Continental Shelf. The types of measures covered by the Arctic Drilling Rules include that operators are required to use equipment which can perform safely in locations that have limited infrastructrure and in extreme weather and ocean conditions. They are also required have the ability to track and respond to changing ice conditions and adverse weather. Of perhaps greater import in determining the nature of actions required in the Arctic was the adoption in the December 2016 of the United States-Canada Joint Arctic Leaders' Statement through which Canada instituted an indefinite moratorium on all future oil and gas activities in all Canadian Arctic waters and the USA adopted an indefinite moratorium on all future oil and gas activities in much of its Arctic waters. (Both moratoria are, however, due to be reviewed after 5 years and the US moratorium may be reversed by the current President, Donald Trump).

There is a further element to demonstrating that a state is acting with due diligence: certain procedural obligations must be complied with.

Procedural Obligations: EIA, and Notification and Consultation

States are subject to the well-recognised obligation to notify and consult potentially affected states of a planned activity which may lead to significant harmful impacts on them (Lac Lannoux Arbitration, 1957). The obligation to notify and consult with states potentially harmed by an activity leads to the obligation to undertake an Environmental Impact Assessment (EIA). The EIA obligation applies where a state is considering authorising a project or activity that may have a significant adverse transboundary impact, in particular on a shared resource (Pulp Mills on the River Uruguay (ICJ 2010)), but also in areas beyond state jurisdiction (Advisory Opinion on Responsibility and Obligations of States with respect to Activities in the Area (ITLOS 2011)). The obligation is also found in a number of treaties, most notably the United Nations Convention on the Law of the Sea 1982,[1] requires EIAs to be conducted "When States have reasonable grounds for believing that planned activities under their jurisdiction or control may cause substantial pollution of or significant and harmful changes to the marine environment" (Article 206). Guidance on how to conduct EIAs can be found in a number of guidelines including the 2009 Arctic Guidelines and the Convention on Biological Diversity, Voluntary Guidelines on Biodiversity-Inclusive Impact Assessment.

The objective of an EIA is to provide decision makers with information on the environmental consequences of proposed activities; enable such information to influence decisions and provide a mechanism for public/stakeholder participation. It must therefore take place before the activity or project begins and, as the Court noted in the Pulp Mills case, it places an ongoing obligation to monitor impacts from these same activities on states.

EIA's rely on the existence of or establishment of scientific data on the environmental baseline associated with a particular time-frame and spatial scale. This allows for natural variability to be accounted for within the assessment, and ensures that the spatial extent of the baseline matches the extent of potential effects for the impact being investigated (Wassmann et al., 2011). While the Arctic Council leads in the establishment of baseline information through, for example, its periodic Arctic Ocean review projects, a lack of ecological information in the Arctic and the impact of global climate change remains. This makes it challenging to set sufficiently concrete environmental baselines for comparison across the timescale of resource extraction within, for example, a project with a potential life of 25-40 years. Despite detailed international guidelines being available (in, for example, the Arctic Guidelines and the CBD Guidelines), they do not provide sufficient detail to address this.

For example, a project developer might record environmental parameters over five years prior to an installation in order to set a 'no impact' baseline for that installation. From the point when installation commences, the pre-installation measurements are used as a frame against which to measure any impacts from the development. However, the background environmental change in the Arctic is so rapid that attributing a change to the project may be problematic. Thus, environmental change within an impacted site could be attributed to that impact, or to ongoing (background) environmental change resulting from climate change and other persistent stressors, or a combination of the two. The current international regime on EIA provides little assistance on how to tackle this issue. For example, the Arctic Guidelines provide "monitoring should preferably be conducted so as to distinguish impacts due to oil and gas activities from other relevant sources" (Arctic Guidelines: 21) but although they also call for natural and other hazards to be taken into account in an EIA they, like other legal documents, cannot or rather do not identify how to address the scientific uncertainties that come with, for example, rapid climate change. In scientific terms this leads to the conclusion that further, extensive and ongoing environmental monitoring in the Arctic is required at both development sites and those free of development. In legal terms this also raises questions of causation. Without robust scientific evidence based on pan-Arctic monitoring, states permitting offshore activities may find themselves open to claims of transboundary environmental harm, imputed to the offshore activity but actually caused by activities elsewhere.

To some extent the need for further research to establish environmental baselines is being met by states acting individually and collectively, in particular through the Arctic Council, to develop understanding of the State of the Arctic Environment. Key reports such as those produced through the Arctic Council Working Groups on Conservation of Arctic Flora and Fauna (CAFF) and Arctic Monitoring and Assessment Programme (AMAP) draw together best scientific understanding. We suggest, however, that further support for the research undertaken by the Arctic Council and others is needed.

To some extent the need to establish baseline information can also be addressed (at least in part) by paying attention to another element of the EIA obligation. The obligation also requires that indigenous peoples be given an opportunity to input into the EIA process (Johnstone, 2014: 168). All EIA processes provide for public participation in some form. The fact that many Indigenous communities rely on Arctic marine resources means that they meet any tests to be counted as public. In the Arctic context this is highly significant as the Indigenous communities will often have a far more sophisticated understanding of the part of the Arctic marine ecosystem they interact with than "traditional" science. At the same time, those conducting the EIA may lack the linguistic skills and cultural understanding to ensure that Indigenous knowledge does feed into the EIA process in an effective manner. Again, the Arctic Council can and does play a role in supporting Indigenous peoples as they feed into the reports produced by its Working Groups and these reports in turn may be of use in informing the EIA process, but this is only part of the story. Further input into EIAs conducted at the national level is also required. Thus legal and scientific questions of how to effectively involve Indigenous and local communities in EIA and other data gathering processes arise. What procedures are required, for example, to ensure that the Indigenous voice is heard and understood in the EIA process?

The next step will be then to evaluate the impact of environmental stressors resulting from a development. In the Arctic, however, calculating both the potential impact of an event and the relative costs of prevention or mitigation will prove scientifically challenging. For example, experience from previous oil spills suggests that predicting the long-term impacts of spills is associated with high uncertainty of outcomes (Lee et al., 2015). Risk assessments and predicting impact outcomes is even more taxing in the Arctic, as the rapidly changing environment with the advent of climate change adds an additional dimension of complexity (Duarte et al., 2012). In part this is because there has been limited opportunity to test cleanup methods in the Arctic, but the complex dynamics of oil/chemical sea ice interactions make it particularly difficult to track the spread of a spill and to predict where it will be transported and how it may begin to degrade. Uncertainty in this area makes it hard for those assessing risks posed by Arctic pollution to predict both the severity of pollution associated with any particular activity, and to plan effective containment and clean up strategies to mitigate environmental harm.

In addition, in the Arctic the EIA process also raises questions in relation to cumulative impacts. Arguably states are required by the UN Convention on the Law of the Sea and other international agreements, to take account of cumulative impacts in marine EIAs (Oude Elferink, 2012). For example, the Convention on Biological Diversity (CBD) Voluntary Guidelines on EIA, which provide guidance on how to interpret and apply Article 14 of the CBD note that the assessment process should include evaluation of (potential) cumulative impacts. The real challenge is, however, in identifying, or assessing the actual impact of potential cumulative impacts in the Arctic. For example, the noise from one individual vessel travelling to and from offshore production facilities may be short-lived and localised, but the transit of multiple vessels along the same route may displace animal populations, or cause migrating animals to avoid the area and to experience increased metabolic costs in order to swim around the affected area (Moore et al., 2012 and references therein). These types of impacts may be felt in any ocean in which they take place, however, in the Arctic their impact may be compounded by the impacts of rapid climate change also affecting Arctic marine species and habitat.

The substantial gaps in our baseline understanding of the Arctic Ocean are amplified by the fact that it is difficult to project how the ecosystem will change in the future. This suggests that predicting how the cumulative impacts of oil and gas developments in the Arctic are distinct from wider environmental change presents a significant challenge, not only to the environmental scientists carrying out the assessments, but also to policy- and law-makers who must develop adequate instruments to regulate these developments within a context of substantial environmental uncertainty. Must, for example, EIAs be conducted for all Arctic marine projects regardless of size because of the potential for significant harm as a result of cumulative impacts? How do we address the fact that cumulative impacts could be exacerbated by the interaction of, for example, chemical or oil pollution and ice? If it is possible that operational oil spills are "captured" by the ice, transported hundreds of miles and "deposited" in another state's EEZ in a single ice melt event, what liability might the emitting state have and what redress would be open to the receiving state? The possibilities these questions raise also lead one to ask if there might be a case for an Arctic wide strategic environmental impact assessment (SEA) to help identify potential cumulative impacts. As an Arctic wide SEA it would, in line with the definition of the Arctic Ocean we use in this paper, cover the ocean north of the latitude 66˚34', a wider area than the regional SEAs recommended in the Arctic Guidelines and the national SEAs recommended by the CBD Voluntary Guidelines. Adopting one might also fit with the recommendations of the Arctic Council Task Force on Arctic Marine Cooperation which include "extending cooperation throughout the entire cycle of marine stewardship: from the planning of scientific research, to … implementation of policy and, to monitoring and assessment of the policy's effectiveness" (Arctic Council, 2017: 4-5).

The challenges of conducting an "effective" EIA we have outlined point to the need for very full notification and consultation procedures with neighbouring states if a state sponsoring a development is to ensure that it can demonstrate that it has acted with due diligence to prevent transboundary environmental harm. As we suggested above, they also point, not just to the need for further scientific research, but to the potential benefits of an Arctic-wide Strategic Environmental Assessment (SEA) to determine where activities could or should not be permitted. The need for an SEA is also emphasized by the problems associated with clean up and recovery from spills and cumulative impacts in the Arctic.

Redress, Clean-Up and Recovery

The final set of issues to consider in the context of transboundary pollution is the question of redress if one state suffers harm as a result of transboundary pollution. Again, as we demonstrate the costs of and indeed possibility of clean up and recovery from pollution incidents or cumulative pollution may be very different in the Arctic than in other oceans and a series of legal and scientific questions arise.

As we have discussed, in comparison with other marine ecosystems, relatively little is known about the Arctic marine ecosystem. What we do know is that there is consensus within the research community that Arctic species are likely to recover more slowly than temperate species following disturbance because many are long lived and reproduce slowly, are more susceptible to toxins than their temperate counterparts, and because of increased toxicity of pollutants in cold waters. Regardless, the magnitude of this effect is unclear (Rice et al. 1978; Suchanek, 1993).

Ecosystem recovery rates following disturbance events may also be slower in the Arctic than in other marine environments. The Arctic has historically been a relatively pristine environment; individual and population recovery rates have only been investigated for a handful of species. However, it is expected that colder temperatures, reduced light levels during the winter months, a truncated growing season, and low nutrient availability may all reduce the recovery rates of species in the Arctic Ocean, extending the temporal footprint of an impact. Furthermore, biodegredation rates for pollutants in the Arctic Ocean are also likely to be slower relative to other marine environments, suggesting that contaminants such as spilled oil will persist in the environment for long periods of time, particularly in Arctic sea ice (Leahy & Colwell, 1990; Atlas, 1981; Atlas et al. 1978).

This scientific uncertainty raises a number of legal issues. Given the untested nature of cleanup and restoration methods in the Arctic, restitution in kind may not be possible. Equally, however, presenting a robust claim for compensation may prove problematic, particularly given the ruling by the International Court of Justice in the *Costa Rica v Nicaragua* case in early 2018. There the court was particularly critical of Costa Rica's methodology for calculating its claim for compensation. It would seem then that any uncertainty in costings might undermine a potential claim for harm arising from transboundary pollution.

A potential solution might be to expand the application of, or adopt measures similar to those found in the Fund Convention which is financed through contributions from importers and exporters of oil. In this case operators or importers/exporters might contribute to a fund to address clean up operations resulting from pollution from offshore installations in the Arctic. An alternative would be to follow the model used in the Antarctic Treaty Protocol on Environmental Protection to the Antarctic Treaty under which a fund is maintained to reimburse the reasonable costs of parties to the treaty in responding to environmental emergencies where the emergency was not caused by actions over where they have jurisdiction (Article 12 of Annex VI to the Protocol). In this case the contributions to the fund are from operators which have failed to take remedial action and where the State Party authorising them has failed to take remedial action (Article 6 of Annex VI to the Protocol.) The danger in following the Antarctic approach is, however, that the operators may dissolve or go bankrupt following an emergency and before arrangements are made for them to pay into any fund. To some degree this risk is mitigated by the liability under Article 6 being joint and severally owed by all operators on a project, nevertheless, there is a clear need to examine the most appropriate ways forward.

International Obligations: Cooperation and the Precautionary Approach

International Law has long recognised the obligation to cooperate. It is contained in many treaties, including the UN Convention on the Law of the Sea 1982 and the Convention on Biological Diversity 1992 and it operates at the regional level as well as between neighbouring states. States' willingness to embrace the obligation to cooperate, particularly at the regional level, is seen in the number of regional seas treaties and programmes around the globe. The UN Environment Programme lists 18 regional seas, including the Arctic, and the Arctic states themselves have recognised the need for further cooperation in the form of an Arctic Regional Programme (Arctic Council, 2017). The application of the obligation to cooperate in the context of marine pollution was also recognised in the Mox Plant Case (MOX Plant, ITLOS (2001)) and reiterated in the Land Reclamation in and around the Straits of Johor Case (ITLOS (2003) and its application in the management of marine resources established in the Request for an Advisory Opinion submitted by the Sub-Regional Fisheries Commission to ITLOS in 2015 (Advisory Opinion by Fisheries Commission (ITLOS (2015)).

As discussed above, the Arctic states have been proactive in cooperating to address pollution from oil and gas activities. The question that arises, however, is: does the obligation to cooperate require states to act when the potential impacts of an activity are still uncertain? We know from past experience that scientific uncertainty may be used as a reason not to enter into new agreements and that even where the scientific community agrees on its knowledge and understanding, political and economic considerations hold more weight in the development of further agreements (Kirk, 2011). Yet in the face of uncertainty, the Arctic states have already accepted the obligation to cooperate and, as indicated earlier, have entered into treaties and adopted guidelines to address some (potential) harms in the Arctic and cooperated in relation to the production and collection of scientific data through, in particular, the Arctic Council. They also adopted the 2017 Agreement on Enhancing International Arctic Scientific Cooperation. This agreement will, hopefully, go some way to help address the gaps in scientific understanding of the marine Arctic. Even so, legal questions arise as to how far the obligation to cooperate requires the Arctic states to work together. Does, for example, the significant risk of harm to the environment coupled with the significant degree of uncertainty around the nature of any impact from oil and gas activities mean that the adoption of a precautionary approach to oil and gas activities is legally or scientifically necessary?

Under the precautionary approach activities presumed to be harmful are not permitted unless they are known not to cause (significant) harm or unless measures have been, or will be taken to prevent harm to the environment. Given the challenges the precautionary approach presents to (international) law, it has not yet been fully accepted as a binding principle of customary international law (Birnie et al., 2009). One might assume therefore that a precautionary approach would not be required. It is, however, found in many treaties aimed at preventing and addressing environmental harm including the Ozone Convention and Montreal Protocol (adopted before there was conclusive proof that the hole in the Ozone Layer was harmful to human health, or to other living organisms (Benedick, 2009)) the London Dumping Convention and its 1996 Protocol, and the 2001 POPs Convention (Sands & Peel 2012). What many of these treaties have in common is that they are addressing particularly harmful activities. One might ask then if the law requires a precautionary approach in such circumstances.

We suggest that these conventions provide good models for the acceptance of a more precautionary approach within the Arctic in relation to oil and gas activities. Alternative sources of oil and gas can, for example, be found elsewhere in the world. Alternative sources of energy such as tide, wind and solar are also becoming more economically viable. Each of these points then to a reason to believe that a precautionary regime to address oil and gas extraction in the Arctic may be a success. The same logic underpinned the success of the Ozone Convention - alternative chemicals existed or could be developed quickly to replace those harming the ozone layer (Benedick, 2009: 24). There is further reason to anticipate success. The Arctic states adopted an Agreement to Prevent Unregulated High Seas Fisheries in the Central Arctic Ocean, which adopts a precautionary approach by, in effect, placing a moratorium on high seas fishing in the Arctic for 16 years. In addition, and as noted earlier, the US and Canada adopted moratoria on future oil and gas licencing within much of their Arctic waters (all in Canada's case). We argue that the same approach should be taken in respect of oil and gas activities. Adopting an Arctic Ocean wide moratorium on further activities (i.e., allowing existing exploitation to continue) would give time to conduct, for example, a thorough Strategic Impact Assessment at the Arctic Ocean level to better decide where such activities should take place. Given that offshore exploitation of oil and gas activities is already taking place in parts of the Arctic, and notwithstanding the Joint US-Canada "moratorium" it is likely that a moratorium on exploration and exploitation on the extended continental shelf and in areas beyond national jurisdiction would have a more realistic chance of success. Whether that would be sufficient to protect the Arctic Ocean from significant harm is, however, open to question.

A precautionary approach could also be achieved in other ways. For example, the Arctic Council could further enhance its existing guidelines on offshore oil and gas activities to take a more precautionary approach, or the Arctic states could adopt a binding set of standards, perhaps brokered through the Arctic Council, which focus on a precautionary approach to offshore energy activities. These could prohibit all exploration and exploitation unless certain circumstances exist or unless certain technical standards are met, in much the same way as the 1996 Protocol to the London Dumping Convention addresses dumping at sea. Which approach would be best in terms of environmental protection and in terms of being most likely to attract state compliance is a question for further research.

Conclusions and Proposals

Our discussion has shown that the potential for further oil and gas activities in the marine Arctic give rise to significant scientific and legal questions. These conclusions outline the questions that remain and while we note the important role played by the Arctic Council and other bodies in addressing existing gaps in knowledge and regulation, we do not here propose the location in which the answers to these questions should be developed: we simply set out the questions that remain.

"Significant Harm" – Significant Questions

We have demonstrated the need for further research to establish what "significant harm" looks like in the marine Arctic both in scientific and legal terms. In particular, we question whether the likely slower degradation and dispersal of, for example, oil in cold and, at times, ice covered waters may increase the impact of the pollutants on the Arctic ecosystem relative to temperate waters. Does, for example, the relative fragility of that ecosystem due to the relatively short food chain and the highly specialised nature of its species make it more vulnerable to pollution, thus turning what might be a minor pollution incident in temperate waters into a major incident in the Arctic? In addition we note that the interactions of pollutants with ice might also turn normally "insignificant" pollution into significant pollution through trapping pollutants in the ice, thus preventing dispersion and ultimately transporting pollutants as a single block to be deposited beyond the national jurisdiction of the state in which the emissions occur. These possibilities point to the need for better scientific understanding of the pollutant/ice interface and sea-ice drift patterns, as well as a need for better understanding of the role of the chain of causation in attributing harm under state responsibility. These questions also raise the possibility that the actions required of coastal states to show that they have acted with due diligence may exceed those required in relevant international treaties particularly where those treaties apply globally and not only in the Arctic.

The Challenges of EIA's – Expanding the Evidence Base

As noted earlier, states are obliged to conduct an EIA where major projects are proposed, but there is an urgent need to expand the Arctic scientific evidence base to ensure such EIAs are effective. First, more detailed baseline data on the Arctic marine environment are required if any such assessments are to be meaningful. Second, due to the rapidly changing environment in the Arctic, continuous monitoring of the Arctic marine environment is essential, in addition to monitoring of sites where development takes place. Without a coordinated, pan-Arctic monitoring programme, it will become increasingly difficulty to disentangle the direct impacts of human activity, for example oil and gas development, from background environmental change, particularly at cumulative impact scales. While Arctic wide monitoring is taking place through the Arctic Council Working Groups, we suggest that this programme should be built upon and expanded in scope, and should take a whole systems approach which places species and physical processes within the wider context of a connected Arctic. This would enable those carrying out EIAs to better evaluate the effects of a development which may be felt across wider spatial and temporal scales, and provide states with a better means to predict transboundary impacts. International programmes such as the Multidisciplinary drifting Observatory for the Study of Arctic Climate (MOSAiC, www.mosaicobservatory.org) are beginning to provide such longer-term information. However, while fundamental research around ocean processes, species, and the physical nature of the Arctic Ocean environment must continue to fill gaps in our basic understanding, we must also begin to apply these findings to the very real possibility of further industrial development in the Arctic, for example from oil and gas activities. This might take the form of a pan-Arctic Ocean Strategic Impact Assessment for petroleum activities. In doing so, we can move towards EIA processes in the Arctic, which are specific to the Arctic context, and in particular, which are better able to assess the cumulative impacts of development as it progresses, and transboundary effects occurring over time

In addition further understanding is needed of the processes to adopt to ensure that Indigenous and local voices are effectively understood in EIA and other monitoring procedures. This raises questions for legal academics – what form of consultation or engagement is most effective in these circumstances?

Clean-Up and Liability

Finally, we raised a series of questions relating to clean-up and liability. Again we argue that further scientific research is needed into the possibility of and costs associated with cleaning up a pollution incident or cumulative pollution in the Arctic and into the feasibility of extending the existing Fund Convention or adopting a convention similar to it or to the provisions of Annex VI to the Anarctic Treaty environmental protocol to apply to Arctic offshore oil and gas activities. As we noted, further understanding is also needed in legal terms of how states can prove or mount a defence against questions of liability for transboundary environmental harm.

The Need for Cooperation and a Precautionary Approach

We argue that cumulatively these questions point to two things: the need for further cooperation between Arctic states and the need for a precautionary approach to further oil and gas activities in the Arctic. We suggested a number of models to adopt to address the need for further cooperation and the need for a precautionary approach. The questions that these possible approaches raise are focussed on the legal requirements to take further steps to cooperate, the legal requirement to adopt a precautionary approach and the question of what an agreement to establish an oil and gas moratorium, or "precautionary standards" might look like.

Acknowledgments

This paper was developed with support of the AHRC Network Grant 'Science Based Regulation of Offshore Energy Installations in the Arctic'. The authors are grateful to the AHRC for its support. In addition, Raeanne G. Miller was supported by the EU Horizon 2020 Research and Innovation Programme under grant agreement 727852 (Blue-Action).

Notes

1. All Arctic states with the exception of the United States of America are party to the 1982 UN Convention on the Law of the Sea (UNCLOS.) For its part, the USA accepts most of the provisions of UNCLOS as representing customary international law.

References

Advisory Opinion on Responsibility and Obligations of States with respect to Activities in the Area (ITLOS Case No. 17 2011).

Advisory Opinion on Legality of the Threat or Use of Nuclear Weapons (Advisory Opinion) [1996] ICJ Rep 225

Afenyo, M., Veitch, B., and Khan, F. (2016). A state-of-the-art review of fate and transport of oil spills in open and ice-covered water.

Agreement on Cooperation on Aeronautical and Maritime Search and Rescue in the Arctic, (Nuuk, 12 May 2011 entered into force January 2013).

Agreement on Cooperation on Marine Oil Pollution, Preparedness and Response in the Arctic (Kiruna, 15 May 2013, not yet in force).

Agreement on Enhancing International Arctic Scientific Cooperation (Fairbanks, 11 May 2017, not yet in force).

Agreement to Prevent Unregulated High Seas Fisheries in the Central Arctic Ocean (Washinton, 17 November 2017, not yet in force).

Arctic Council, Arctic Monitoring and Assessment Programme Assessment 2007: Oil and Gas Activities in the Arctic – Effects and Potential Effects. Volume 2 (Arctic Monitoring and Assessment Programme (AMAP), Oslo, Norway, 2010). Vii + 277 pp.

Arctic Council, Arctic Monitoring and Assessment Programme, AMAP Assessment Report: Arctic Pollution Issues, Chapter 10: Petroleum Hydrocarbons (Arctic Monitoring and Assessment Programme (AMAP), Oslo, Norway1998), pp. 661-702.

Arctic Council, Protection of the Arctic Marine Environment Working Group, Arctic Offshore Oil and Gas Guidelines (Arctic Council, 2009).

Arctic Council, Protection of the Arctic Marine Environment Working Group Arctic Offshore Oil and Gas Guidelines: Systems Safety Management and Safety Culture (Arctic Council, 2014).

Arctic Council Task Force on Arctic Marine Cooperation, (2017) Report to Ministers of the Task Force on Arctic Marine Cooperation (Arctic Council Task Force on Arctic Marine Cooperation, Fairbanks USA).

Atlas, R.M. (1981). Microbial degradation of petroleum hydrocarbons: an environmental perspective. Microbiological Reviews, 45(1), pp. 180-209.

Atlas, R., Horowitz, A., and Busdosh, M. (1978). Prudhoe crud oil in Arctic marine ice, water, and sediment ecosystems: Degradation and interactions with microbial and benthic communities. Journal of the Fisheries Research Board of Canada, 35(5), pp. 585-590.

Beegle-Krause, C. J., Simmons, H., McPhee, M., Daae, R. L., and Reed, M. (2013). Fate of dispersed oil under ice. Final Report 1.4: Literature Review. Arctic Oil Spill Response Technology Joint Industry Programme. 48 pp.

Birnie, P., Boyle, A., Redgwell, C *International Law and the Environment* 3rd ed (Oxford University Press 2009.

Benedick, RE *Ozone Diplomacy: New Directions in Safeguarding the Planet*, Harvard University Press, 2009.

Blanken, H., Tremblay, L., Gaskin, S., and Slavin, A. (2017). Modelling the long-term evolution of worst-case Arctic oil spills. Marine Pollution Bulletin, 116(1-2), pp. 315-331.

Code for the Construction and Equipment of Mobile Offshore Drilling Units (IMO Resolution A.1023(26), 2 December 2009).

Convention on Biological Diversity (adopted 5 June 1992; entered into force 29 December 1993) 1760 UNTS 79.

Convention on Biological Diversity Conference of the Parties 8, Voluntary Guidelines on Biodiversity-Inclusive Impact Assessment, CBD COP 8, Decision VIII/28 UNEP/CBD/COP/DEC/VIII/28 on 15 June 2006.

Darnis, G., Robert, D., Pomerleau, C., Link, H., Archambault, P., Nelson, R. J., Geoffroy, M., Tremblay, J., Lovejoy, C., Ferguson, S. H., Hunt, B. P. V., and Fortier, L. (2012). Current state and trends in Canadian Arctic marine ecosystems: II. Heterotrophic food web, pelagic-benthic coupling, and biodiversity. Climatic Change, 115(1), pp. 179-205.

Duarte, C., Agustí, S., Wassmann, P., Arrieta, J., Alcaraz, M., Coello, A., Marbà, N., Hendriks, I., Holding, J., García-Zarandona, I., Kritzberg, E., and Vaqué, D. (2012). Tipping elements in the Arctic marine ecosystem. AMBIO 41(1), pp. 44-55.

Environmental Protocol to Antarctic Treaty (adopted 4 October 1991; entered into force 14 January 1998) 30 ILM 1455 (1991).

Gosselin, M., Levasseur, M., Wheeler, P. A., Horner, R. A., and Booth, B. C. (1997). New measurements of phytoplankton and ice algal production in the Arctic Ocean. Deep Sea Research II, 44(8), pp. 1623-1644.

Duvic-Paoli, L.-A., and Viñuales, J.E., 'Principle 2 Prevention ' in Jorge E Viñuales (ed), The Rio Declaration on Environment and Development: A Commentary (OUP 2015).

Forsgren, E., Christensen-Dalgaard, S., Fauchald, P., Järnegren, J., and Naesje, T. (2009). Norwegian marine ecosystems – are northern ones more vulnerable to pollution from oil than southern ones? NINA Report 514, 32 pp.

Hoegh-Gulberg, O., and Bruno, J.F. (2010). The impact of climate change on the world's marine ecosystems. Science 328 (5985), pp. 1523-1528.

Illulisat Declaration on the Arctic Ocean, Adopted 28 May 2008.

International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage (adopted 27 November 1992 entered into force 30 May 1996) (Fund Convention) UK Treaty Series No. 87 (1996) Cm 3432.

International Convention on Oil Pollution Preparedness, Response and Cooperation (adopted 30 November 1990; entered into force 13 May 1995) 1891UNTS 77.

Johnstone, Rachael Lorna (2014). *Offshore Oil and Gas Development in the Arctic under International Law : Risk and Responsibility*, BRILL.

Jones, E. Peter. (2001). "Circulation in the Arctic Ocean" 20:2 Polar Research, 139-146,

Kaiser, M. J., Attrill, M. J., Jennings, S., Thomas, D. N., Barnes, D. K. A., Brierley, A. S., Hiddink, J. G., Kaartokallio, H., Polunin, N. V. C., and Raffaelli, D. G. (2011). Marine

Ecology: processes, systems, impacts, 2nd Edition. Oxford University Press, Oxford, UK. xxviii + 501 pp.

Kirk, E.A., (2011) "Marine Governance, Adaptation and Legitimacy" 22 Yearbook of International Environmental Law pp. 110-139.

Lac Lanoux Arbitration (France v. Spain) (1957) 12 R.I.A.A. 281.

Land Reclamation in and around the Straits of Johor (Malaysia v. Singapore), Provisional Measures, Order of 8 October 2003, ITLOS Reports 2003, 10.

Legality of the Threat or Use of Nuclear Weapons, Advisory Opinion, I.C.J. Reports 1996, 226.

Leahy, J., and Colwell, R. (1990). Microbial degradation of hydrocarbons in the environment. Microbiological Reviews, 54(3), pp. 305-315.

Lee, K. (*chair*), Boufadel, M., Chen, B., Foght, J., Hodson, P., Swanson, S., and Venosa, A. (2015). Expert panel report on the behavior and environmental impacts of crude oil released into aqueous environments. Royal Society of Canada, Ottawa, ON. ISBN: 978-1-928140-02-3.

(London Dumping) Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (adopted 29 December 1972; entered into force 30 August 1975) 1046.UNTS 138 and the 1996 Protocol to the Convention on the Prevention of the Marine Pollution by Dumping of Wastes and Other Matters (adopted 7 November 1996; entered into force 24 March 2006) (14 November 1996) IMO Doc. LC/SM 1/6.

Moore, S. E., Reeves, R. R., Southall, B. L., Ragen, T. J., Suydam, R. S., and Clark, C. W. (2012). A new framework for assessing the effects of anthropogenic sound on marine mammals in a rapidly changing Arctic. BioScience 62(3), pp. 289-295.

MOX Plant (Ireland v. United Kingdom), Provisional Measures, Order of 3 December 2001, ITLOS Reports 2001, 95.

Norwegian Petroleum Directorate (2018). Online Fact Directory, https://www.norskpetroleum.no/en/facts/field/. Accessed 31/05/2018.

Oude Elferink, A.G.,'Governance Principles for Areas beyond National Jurisdiction' (2012) 27 International Journal of Marine and Coastal Law 205.

(OSPAR) Convention for the Protection of the Marine Environment of the North-East Atlantic (adopted 22 September 1992; entered into force 25 March 1998) 2354 UNTS 67.

Overland, J. E., and M. Wang (2013), When will the summer arctic be nearly sea ice free?, 40 Geophys. Res. Lett., 2097–2101.

Overland, J., Wang, M., Walsh, J. and Stroeve, J. (2014). Future Arctic climate changes: Adaptation and mitigation time scales. Earth's Future 2(2), pp. 68-74.

Payne, J.R., Mcnabb, G.D., and Clayton, J.R. (1991). Oil-weathering behavior in Arctic environments. Polar Research, 10(2), pp. 631-662.

Petrich, C., Karlsson, J., and Eicken, H. (2013). Porosity of growing sea ice and potential for oil entrainment. Cold Regions Science and Technology, 87, pp. 27-32.

Post, E., Bhatt, U. S., Bitz, C. M., Brodie, J. F., Fulton, T. L., Hebblewhite, M., Kerby, J., Kutz, S. J., Stirling, I., and Walker, D. A., (2013). Ecological consequences of sea-ice decline. Science 341(6145), pp. 519-524.

Protocol on Environmental Protection to the Antarctic Treaty (1991) Annex VI Liability Arising from Environmental Emergencies adopted 2005 not yet in force. Available at https://www.ats.aq/e/ep.htm.

Pulp Mills on the River Uruguay case (Argentina v. Uruguay), (Judgment) [2010] ICJ Rep. 14.

Request for an Advisory Opinion submitted by the Sub-Regional Fisheries Commission, ITLOS Case no. 21, April 2015.

Rice, S., Korn, S., and Karinen, J. (1978). Lethal and sublethal effects on selected Alaskan marine species after acute and long-term exposure to oil and oil components. Outer Continental Shelf Energy Assessment Program. Contract #R7120822 Final Report. Northwest and Alaska Fisheries Center, National Marine Fisheries Service, NOAA. 32 pp.

Philippe Sands and Jacqueline Peel with Adriana Fabra and Ruth MacKenzie Principles of International Environmental Law 3rd ed (Cambridge, 2012).

Schweiger, A., Lindsay, R., Zhang, J., Steele, M., Stern, H., Kwok, R. (2011). Uncertainty in modeled Arctic sea ice volume. Journal of Geophysical Research: Oceans. 116(C8), pp. C00D06.

Stockholm Convention on Persistent Organic Pollutants (adopted 22 May 2001; entered into force 17 May 2004) 2256 UNTS 119.

Suchanek, T. (1993). Oil impacts on marine invertebrate populations and communities 1. American Zoologist, 33, pp. 510-523.

United Nations Convention on the Law of the Sea (adopted 10 December 1982; entered into force 16 November 1994) 1833 UNTS 3.

United States-Canada Joint Arctic Leaders' Statement https://pm.gc.ca/eng/news/2016/12/20/united-states-canada-joint-arctic-leaders-statement.

USA Oil and Gas and Sulfur Operations on the Outer Continental Shelf-Requirements for Exploratory Drilling on the Arctic Outer Continental Shelf A Rule by the Safety and Environmental Enforcement Bureau and the Ocean Energy Management Bureau on 07/15/2016 81 FR 46477.

Vandermeulen, J. H., and Gordon, D. C. (1976). Reentry of 5-year-old stranded Bunker C fuel oil from a low-energy beach into the water, sediments, and biota of Chedabucto Bay, Nova Scotia. Journal of the Fisheries Research Board of Canada, 33(9), pp. 2002-2010.

Vienna Convention for the Protection of the Ozone Layer (adopted 22 March 1985; entered into force 22 September 1988) 1513 UNTS 293 and Montreal Protocol to Vienna Convention for the Protection of Ozone Layer on Substances that Deplete the Ozone Layer (adopted 16 September 1987; entered into force 1 January 1989) 1522 UNTS 28.

Wassmann, P., Duarte, C. M., Agustí, S., and Sejr, M. K. (2011). Footprints of climate change in the Arctic marine ecosystem. Global Change Biology, 17(2), pp. 1235-1249.