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'The role of science, technology and engineering in the regulation of Arctic oil spills: an interdisciplinary approach'

By

Tina Soliman Hunter

The role of science, technology and engineering in the regulation of Arctic oil spills: an interdisciplinary approach

Professor Tina Hunter[1]

1. Introduction

According to an assessment of Arctic petroleum resources by the US Geological Survey, more than 400 onshore fields have extracted 40 billion barrels (bbl) of oil, 1136 trillion cubic feet (Tcf) of gas and 8 billion bbl natural gas liquids to date. [2] A further assessment of the offshore Arctic geology concludes that approximately 30% of the world's undiscovered gas and 13% of undiscovered oil lies in primarily on the Arctic continental shelf in less than 500m of water,[2] of which the lion's share is located in the seas of the Euro-Barents Arctic.[3] To date, most of the exploitation of offshore Arctic oil and gas has occurred in the EuroBarents Region, and includes the Norwegian fields Goliat and Snøhvit, and the Russian Yamal and Prirazlomnoye developments. There are a number of other fields in the area that are slated for development, especially the giant Shtokman Field, as well as highly prospective new areas, including the Fedinsky High straddling the Norway-Russia Maritime Border.

Given the huge petroleum resources in the area, the increased level of exploitation of petroleum, and the risk and consequences of an oil spill associated with such activities, it is critical that the oil spill prevention, preparedness and response (OSPPR) framework considers not only legal regulation, but also incorporates the necessary interdisciplinary knowledge and linkages. Adopting this regulatory framework will ensure best practice in regulating OSPPR. Therefore, this paper examines two main issues. Firstly, it provides an overview of sources of oil spills in the Arctic, and the legal framework relating to spills from petroleum activities. Secondly, it provides a brief overview of the interdisciplinary issues to be considered when seeking to regulate extraction activities in the Arctic to prevent and respond to oil spills.

2. Sources of oil spills in the Arctic

The two main sources of oils spill in the Arctic marine environment is that of petroleum platforms and ships as illustrated in figure 1 below:

[1] Professor of Petroleum Law and Director of the Centre for Energy Law, University of Aberdeen. Corresponding email: thunter@abdn.ac.uk [2] Donald Gautier et. al., 'Assessment of Undiscovered Oil and Gas in the Arctic' (2009) 324 *Science* 1175 – 1179, 1175.

[2] This means that estimates of undiscovered, technically recoverable oil and gas in the Arctic are approximately 90 billion bbl oil, 1670 Tcf gas and 44 billion bbl of natural gas liquids. See Gaultier, Ibid.

[3] The Euro-Barents Arctic is the area of Norway and Russia, and includes the Barents Sea, Kara Sea, and the White Sea.

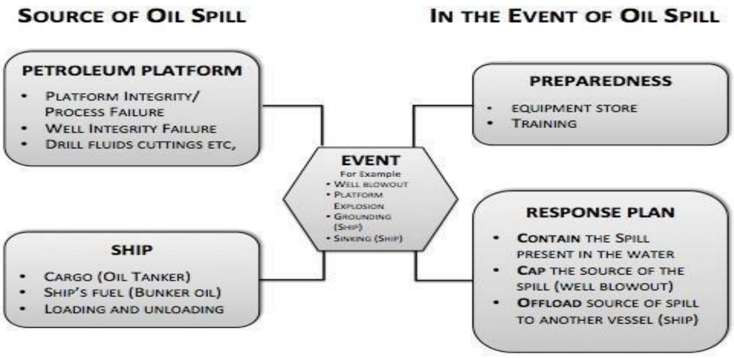

Figure 1: Oil Spill sources and events (Source: Compiled by Author)

2.1 Petroleum Platforms and Facilities (PPF)

When undertaking petroleum exploitation, there are several possible sources of oil pollution. In particular, there are three main sources of oil spill: well blowouts and associated hydrocarbon release; platform failure; and operational discharges. Of these, operational discharges such as drill fluids and cuttings contribute a small volume oil spill in the environment. A major contributor is that of well blowouts, with platform incidents also contrbuting to oil spills.

2.1.1 Well Blowouts

When undertaking drilling operations, a well blowout (also known as loss of well control/integrity) is a source of oil pollution. Such loss of control can range from minimal, causing a minor oil spill, to major well blowouts that have resulted in huge oil spills with enormous environmental and social consequences.

In the period that offshore oil production has occurred, there have been four incidents of note that have had a major impact on the law regulating oil spills from well blowouts. The first was the 1977 *Ekofisk Bravo* well blowout, which occurred during maintenance work on a production well located in the North Sea.[4] The uncontrolled blowout and oil spill continued for seven days until the well was killed.[5] The second spill of significance, and the second worst in terms of volume spilled, was the Ixtoc 1 well blowout and oil spill that occurred on 3 June 1979 when an exploratory well being drilled by the Semi-submersible drilling rig the *Sedco 135-F*, was being drilled in the Bay of Campeche in the Gulf of Mexico in 50m of water.[6] The well was capped some ten months later on 23 March 1980, with 140 million gallons of oil spilling into the Gulf of Mexico.[7]

The third oil spill of significance was the Montara Blowout and oil spill ('Montara') on 21 August 2009.[8] It occurred in a remote area northwest off the Western Australian coast, approximately 690km from Darwin. The spill continued until 3 November 2009 (a total of 74 days), when a relief well capped the leaking well.

[4] Petroleum Safety Authority, Norway, *Safety – Status and Signals, 2012-13: Ekofisk Bravo, (1977)* (2013) http://www.ptil.no/articles-in-safety-statusandsignals2012-2013/ekofisk-bravo-1977-article9121-1095.html accessed 11 March 2017.
[5] A well kill refers to placing well mud of sufficient density to stop the flow of hydrocarbons from a well. See Schlumberger *Oilfield Glossary* http://www.glossary.oilfield.slb.com/Terms/k/kill.aspx accessed 25 March 2017.
[6] Bureau of Land Management and ERCO, *Ixtoc oil spill assessment: final report executive summary* (1982) http://invertebrates.si.edu/boem/reports/IXTOC_exec.pdf
[7] Ibid
[8] All other major oil spills in Australia have been the result of ship-sourced pollution. For details of all major oil spills in Australia's waters in the last thirty years, refer to Australian Maritime Safety Authority, *Major Oil Spills in Australia* (2009) <http://www.amsa.gov.au/Marine_Environment_Protection/Major_Oil_Spills_in_Australia/> at 21 April 2010.

Approximately 14,000 gallons of oil leaked daily, with a total of approximately 1.5 million gallons (over 44,000 barrels) of oil leaked from the well.[9] Although the Montara incident resulted in no deaths on the oil platform, and minimal environmental impact in Australian waters,[10] one of the significant issues relating to this blowout and subsequent oil spill was the length of time required to cap the well.

The fourth, and perhaps most internationally well-known incident is the well blowout on the Deepwater Horizon (DWH) drilling rig and subsequent oil spill in the Gulf of Mexico on 20 April 2010 at the BP operated Macondo Prospect. Following a loss of well integrity, there was an explosion on the Deepwater Horizon

drilling rig, causing the death of eleven rig workers and rupturing the riser at the seabed. The well was capped 87 days later on 15 July 2010, resulting in a spill of approximately 134 million gallons of oil.[10]

2.1.2 Platform Failure

The *Piper Alpha* platform disaster in the British Sector of the North Sea, which occurred on 6 July 1988 as a consequence of a series of events, was in part attributable to poor decision-making and human error. An explosion engulfed the platform in a catastrophic fire, causing the death of 165 men on board the platform, and two rescue crew members.[11] This event, seen as a failure of technical and organisational factors,[12] highlighted the need for robust processes and systems, which has developed into process safety, a disciplined framework for managing the integrity of operating systems and processes that work worth hazardous substances such as oil and gas.[13] Whilst the *Piper Alpha* disaster is synonymous with a failure of process safety, it also was a source of an oil spill as a result of the platform fire and damage to the subsea production

wells stemming from destruction of the platform, causing a significant oil spill lasting several weeks.[14] Given the enormity of the loss of life on the *Piper Alpha*, scant attention has been paid to the oil spill aspects of the disaster. Although a rare occurrence, failures in process safety leading to platform fires and damage to wells has the potential to be a source of offshore oil spills.

2.2 Ships

Ships provide two sources of oil spills. The first source is that of oil tankers, the large ships which transport oil from the place of production to that of consumption. During the last fifty years, since the grounding and subsequent spill from the Torrey Canyon in 1967 there have been numerous oil spills from tankers that have caused severe environmental pollution. The cargos that have been lost as a result of oil spills have been staggering, ranging from 10-88 million gallons of oil.

Although tanker accidents are the largest source of ship-based oil spills other ships, usually cargo ships, also contribute to marine oil spills though the release of bunker (fuel) oil. Most often such accidents are groundings (such as the Shen Neng 1 which grounded on the Great Barrier Reef), collision, or mechanical damage/failure.

[9] Australian Maritime Safety Authority, *Major Oil Spill: Montara Well Head Platform* (2009) Australian Maritime Safety Authority, *Major Oil Spill: Montara Well Head Platform* (2009) http://www.amsa.gov.au/Marine_Environment_Protection/Major_Oil_Spills_in_Australia/Montara_Wellhead/index.asp> at 14 April 2017. [10] The spill did not reach the Australian coastline due to its distance from the Australian coast, nor were there any discernable impacts on wildlife. However, there have been numerous allegations from West Timor fisherman of impact on fisheries and sea weed farming, leading to a class action brought by West Timorese fishermen. See Gabrielle Dunlevy, 'Indonesian seaweed farmers to file $200m class action over Timor Sea oil spill' (2016) *The Guardian*, https://www.theguardian.com/world/2016/aug/02/indonesia-seaweed-farmers-class-action-timor-sea-montara-oil-spill-2009-australia at 15 April 2017.

[10] An estimation of the amount of oil released varies. For this chapter the estimation from the *Smithsonian National Museum of Natural History Ocean Portal* has been selected due to independence of source. See http://ocean.si.edu/gulf-oil-spill accessed 22 March 2017.

[11] Lord Cullen, *The Public Inquiry into the Piper Alpha Disaster, Vols. 1and 2* (Report to Parliament by the Secretary of State for Energy by Command of Her Majesty, November 1990).

[12] M Elisabeth Paté-Cornell, 'Learning from the Piper Alpha accident: a postmortem analysis of technical and organisational factors' (1993) 13 (2) *Risk Analysis*, 215232.

[13] Bob Skelton, *Process Safety Analysis: an Introduction* (1997) Institute of Chemical Engineers.

[14] Find ref

Whilst the contribution of these types of incidents is much less than that of tankers, they are nonetheless a source of oil spill, since they often occur near shore, in ports or near loading facilities.

3. Regulating Arctic oil spills

The legal regime regulating oil spills depends on three things: prevention, planning (also known as preparedness) and response. Together this regime is known as PPR, and the role of each component is illustrated in figure 2 below.

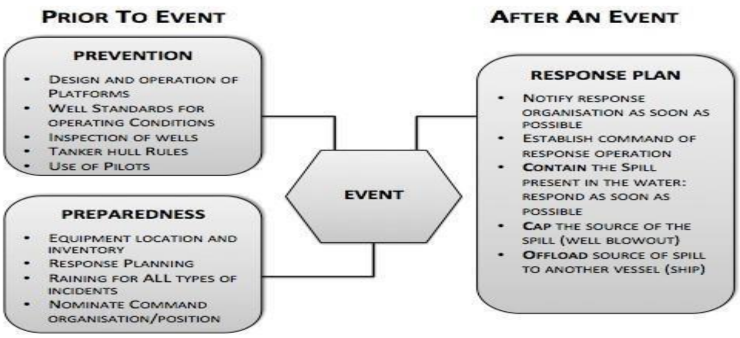

Figure 2: Oil Spill prevention, preparedness and response (Source: Compiled by Author)

Prevention is a proactive action that is designed to ensure that an oil spill does not occur in the first place. Such legal requirements to prevent an oil spill from occurring in shipping include the use of pilots on ships in hazardous waters and the requirement for a double hull on oil tankers. For petroleum facilities, such preventative legal requirements include risk reduction for platforms and use of standards for the integrity of wells. Responding to oil spills requires two primary actions: containing the oil that is spilling into the marine environment, and controlling the source of the oil spill.

Controlling the source of the spill varies greatly with the type of oil spill. With tanker accidents, history demonstrates that often there is little opportunity to remove the cargo. However, once a ship has discharged its cargo of oil, there is nothing left to spill. However, this is evidentially not the case with oil spills from oil platforms due to well blowouts. If a well blows out, particularly if it is a high-pressure well (particularly due to depth of the well), the well will continue to spill oil until it is capped.[15].

The international legal regime governing oil spills needs to ensure that it adequately addresses all the issues that may arise with regard to oil spills. There are several international instruments related to oil spill prevention, preparedness and response, and two worthy of mention: the *United Nations Convention on the Law of the Sea* (UNCLOS) and the *International Convention on Oil Pollution Preparedness, Response and Cooperation* (OPRC).

[15] As demonstrated in section 2.1 above, the Ixtos 1 and DWH well blowouts contributed over 130 million gallons of oil, and would have continued to keep leading but for the wellbeing capped. The concern with spills from oil wells is the amount of time it takes to cap a well. Both the Montara and DWH blowouts took over two months to cap, with the Ixtos 1 well taking almost ten months to cap. It is this delay in capping a well, and the continuous, infinite source of oil that makes platform spills the gravest source of oil spills

Article 193 of UNCLOS confers on States a general right to develop their natural resources, including petroleum resources. As a specific source of marine pollution, oil spills are not articulated or regulated under UNCLOS, although a number of articles impose obligations in relation to marine pollution. Article 192 imposes a general obligation to protect and preserve the marine environment. Article 194 imposes the obligation on a State to implement measures to prevent, reduce and control marine pollution from *any source*, including the use of best practicable means at their disposal to,[16] 'ensure that activities under their jurisdiction or control are so conducted as not to cause damage by pollution to other States and their environment, and that pollution arising from incidents or activities under their jurisdiction or control does not spread beyond the areas where they exercise sovereign rights'.[17]

The OPRC was motivated by the Torrey Canyon oil spill off the West Coast of the UK, and provides an international law regime underpinning for the obligations articulated in UNCLOS. The OPRC provides an international framework to prepare for and respond to major oil pollution incidents, [19] and to facilitate international co-operation and mutual assistance. It applies to any vessels of any type operating in the marine environment as well as any fixed or floating offshore installation or structure engaged in oil and gas activities.[21]

The additional *Protocol on Preparedness, Response and Co-operation to Pollution Incidents by Hazardous and Noxious Substances, 2000* (the 'Protocol') extends this international legal framework to encompass marine pollution incidents involving hazardous and noxious substances.

Aside from the hard law instruments outlined above, the Arctic Council, has developed its second binding agreement – the *Agreement on Cooperation on Marine Oil Pollution Preparedness and Response in the Arctic 2013* (the 'Agreement'), which was signed by the eight Arctic ministers in 2013.[17] Although normally a soft law body (where Agreements between member parties are not binding), the Arctic Council has made an exception by entering into a biding agreement for marine oil pollution.

A unifying feature of these international instruments is the reliance states enacting national domestic legislation to implement the requirements for OSPPR. Therefore, the main instrument implementing OSPPR is found within each Arctic state's national petroleum regulation framework. Considerations for the national legal framework include the following:

- Is the legal framework prescriptive or rule based? Does it have Arctic-specific rules?
- Does the framework utilise risk assessment or prescribe set requirements for HSE?
- Does the law underpin, or is it the umbrella?

4. The role of science, technology and engineering in preventing oil spills

Engineering

One of the critical issues relating to the prevention of well blowouts is the engineering standard associated with the regulation of well integrity - does the legal framework require the use of best practice or mere 'good oilfield practice' for the integrity of wells? This includes analysis of the type of engineering standards for wells: are they prescriptive industry standards,[18] or more holistic national requirements?[24] Furthermore, such engineering requirements are likely to alter in the Arctic compared to other exploration and production areas due to the impact of temperature and ice on materials. *Geosciences/reservoir engineering*

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[16] Article 194 (1) of UNCLOS. Italics added by author.
[17] UNCLOS, article 194 (2). [19] OPRC article 1. [21]
OPRC article 2.
[17] The Members of the Arctic Council are Canada, Denmark, Finland, Iceland, Norway, Russia, Sweden and the USA, as well as six Permanent Participants, organisations representing the Arctic indigenous peoples.
[18] Such as API Standard 65 Part 2 (*Isolating potential Flow Zones During Well Construction*) [24] Such as NORSOK DS-010 on *Well integrity in Drilling and Well Operations.*

The importance of geosciences and reservoir engineering in exploration cannot be understated. It is critical that reservoir modeling (including stratigraphic sequences, pressure, temperature, well placement, etc) are taken into consideration, particularly in the oil exploration phase, to ensure that exploration wells are correctly placed and constructed to take into account pressure and temperature of geology.

Psychology

The psychology and organisational culture/behaviour of an organisation, particularly in relation to health safety and environment, is critical in oil spill prevention and response. Investigation into the conduct of BP in the aftermath of *Deepwater Horizon* demonstrated failings in the organisational culture and attitude towards safety.[19]

5. The role of science, technology and engineering in oil spill preparedness and response *Logistics and planning*

The remote location of the Arctic and the poor infrastructure of the region means that any coordinated preparation and response to oil spills requires logistics and planning. Considerations include:

- Where will oil spill response materials be sited?
- What organisation and level will be responsible for coordinating and leading response? Will it be national, regional or local? Will it be private companies or government?
- What sort of training and preparation will be undertaken for oil spill response? Will it be for small or major incidents?
- How will extra/necessary materials be moved to needed site? How will this differ in different seasons? For instance, if a capping stack is required to effect a well kill, which organisation will organize? What logistics will be required – how will it be flown in, what airport, and how will it be transported to site?

GIS

The modeling and prediction of the spread of oil spills is essential in order to firstly predict how oil will move, and also to muster and coordinate response. Therefore, it is essential that GIS is available to regulators and coordinators to enable predictions of oil spill scenarios for planning purposes, and, should there be a spill, available to assist in the mapping and prediction of spill location.

Political Science and International Relations

The establishment and continuation of cooperative arrangements between governments is essential for the management of Arctic petroleum activities, especially in the Euro-Barents Region, where there is likely to be joint development of petroleum resources between Russia and Norway. Such activities will require delicate negotiation and mutual decision-making, built on trust and knowledge. Furthermore, should an oil spill occur, and with it trans-boundary pollution, international relations and politics will be essential to maintain cordiality between the nations affected and maintain cooperative arrangements – regional agreements for materials?

Science

Responses to an oil spill include three main methods: physical (boom and skim); chemical (the use of dispersants); or natural (utilising nature to breakdown the oil). The regulation of the implementation of these responses in the Arctic depends on the physical environment, which requires the input of scientific knowledge regarding the physical environment, the action of chemicals in that environment, and the behaviour of oil in climatic conditions. Without such knowledge, the regulation of oil spill prevention and response will be

[19] See Andrew Hopkins, *Disastrous Decisions: the Human and Organisational Causes of the Gulf of Mexico Blowout* (2012); Tom Bergin, *Spills and Spin: The Inside Story of BP* (2012).

impossible. Therefore, States must take a precautionary and scientifically informed approach to deploying oil spill response regulation and policy. *Engineering*

One of the greatest difficulties with a well blowout is capping a well. This raises many engineering questions: what is the best approach to capping a well? What materials are required? What design is likely to be suited to the cold environ where methane hydrate formation is a problem? Such questions need to be addressed from an engineering standpoint in order to be able to formulate oil spill response regulation.

6. Conclusion

When seeking to regulate oil exploitation in the arctic, it is essential to understand the role that other disciplines play. Even though the law provides both the umbrella and the foundation for OSPPR, it cannot possibly effectively and comprehensively regulate without the input of other disciplines. There is a need for a multidisciplinary assessment that includes natural sciences, social sciences and engineering to ensure that the Arctic natural environment is protected from the impacts and effects of oil and gas exploration and production.

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