Operating in the Arctic Ocean: Environmental Realities and Technical Challenges

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Session III
Arctic Ocean Technology: Utilizing R&D to Overcome Resource Development Challenges

Introduction

This presentation is being provided by a new company called RESTCO which is focused on remote community sustainability starting with energy security but including the necessary local social and community development needed to create healthy and long term solutions. RESTCO publishes monthly a web newsletter called "Spill Monitor". Check our website for more information.

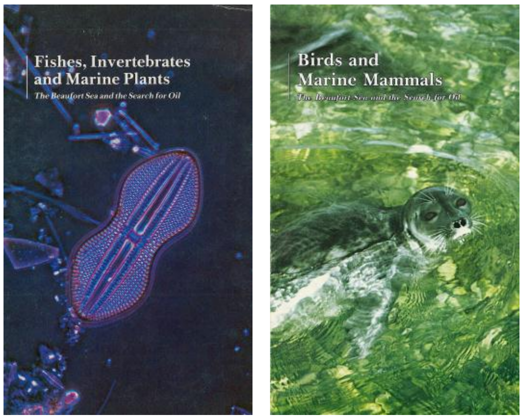
The presentation will be divided into three parts: first, some background on R&D in the Arctic related to oil and gas development that sets the scene where these activities are to be undertaken followed by a short account of the current process to regulate the oil and gas industry in the Canadian Arctic; second, a review of oil industry practices and technologies with regard to offshore drilling/spill cleanup capabilities especially in the Arctic; and third, some considerations about possible R&D directions for safer and lower risk offshore drilling in the Arctic.

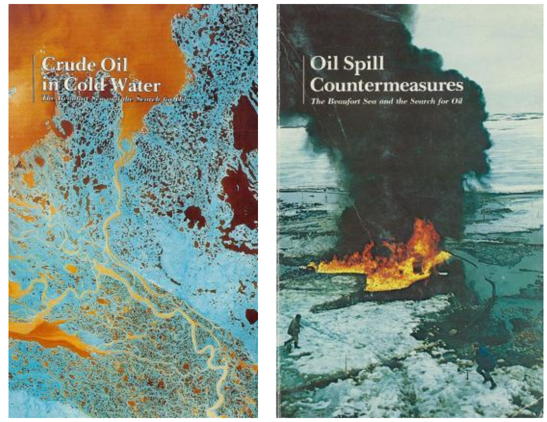
The conclusions are presented in the form of some recommendations for how best to approach oil spill remediation in the Arctic Ocean. It will become clear from this presentation that industry does not possess the means to cleanup oil spills in ice covered waters at this time. It is therefore essential that R&D be undertaken before such industrial activities begin in earnest. In some countries oil exploration in the Arctic is already underway which places the whole Arctic Ocean in danger due to the lack of suitable technology for dealing with spills. The paper ends with a reference section that covers the subject of oil spill cleanup technology and background information about the impact of oil spills.

In fact even under Soviet rule in the 1970s, the scientists in Russia were well aware of this risk. In a paper (1) from 1976 by Acad. A. F. Treshnikov, Director of the Arctic and Antarctic Institute in what was then Leningrad, he concluded with the following:

> *"In Alaska and other northern areas where extensive oil development has been started, there exists a real threat that the arctic environment could change as a result of oil spillage. Conceivably, part of the recovered oil could spill over water and ice to become incorporated into the gyral over the Canadian Basin, where it might accumulate for many years."*

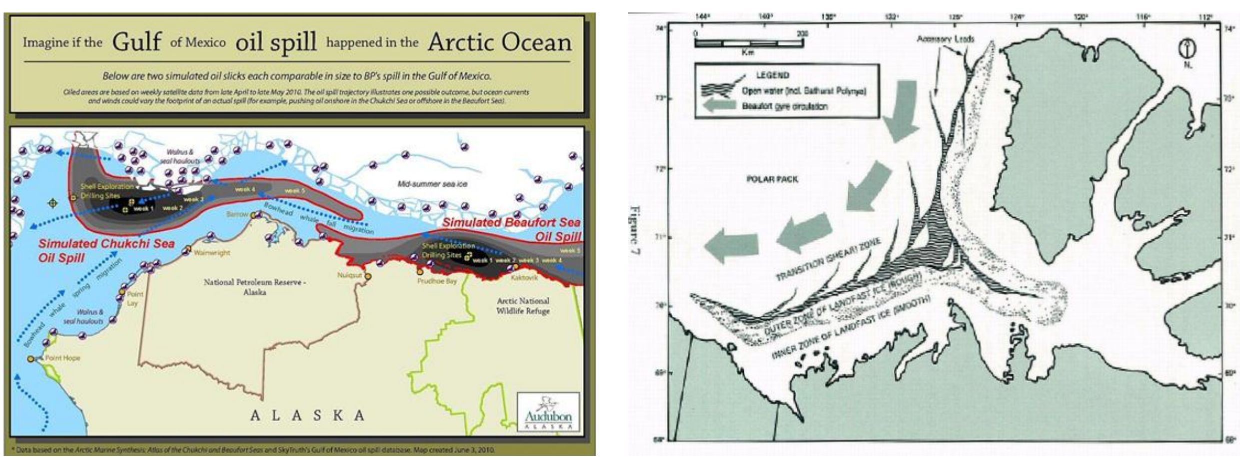
Part 1 - A glimpse of R&D done in the Beaufort Sea 30 years ago and the National Energy Board report on Offshore Drilling in the Arctic Ocean





FIGURES 1 and 2 - Summary reports of the Beaufort Sea Project (2)

These Figures are the covers of summary books indicating that early in the oil and gas industrial development in the Canadian Arctic in the mid-1970s, a major study took place called the Beaufort Sea Project. It was in today's dollars approximately a $50 million dollar multi-disciplinary study funded by the Federal Government and Industry. Some 45 technical reports were completed and five summary books published. This is basic information related to the environment where industrial development was underway in the 1970s and is again being planned. RESTCO has made these very important reports that were out of print available on our web site. We have also suggested that all the technical reports be put on-line and this is being done by Fisheries and Oceans Canada from their Victoria location.



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FIGURES 3a/b - Illustration of ice types and currents found in the Beaufort Sea

The ice regime in the Arctic consists of three principal regions: the outer polar pack that moves in a clockwise direction throughout the year and includes multiyear ice. The inner shore fast ice that is locked in place and consists of first year ice, and the transition zone ice that exists between the above two zones and includes leads and both types of ice.

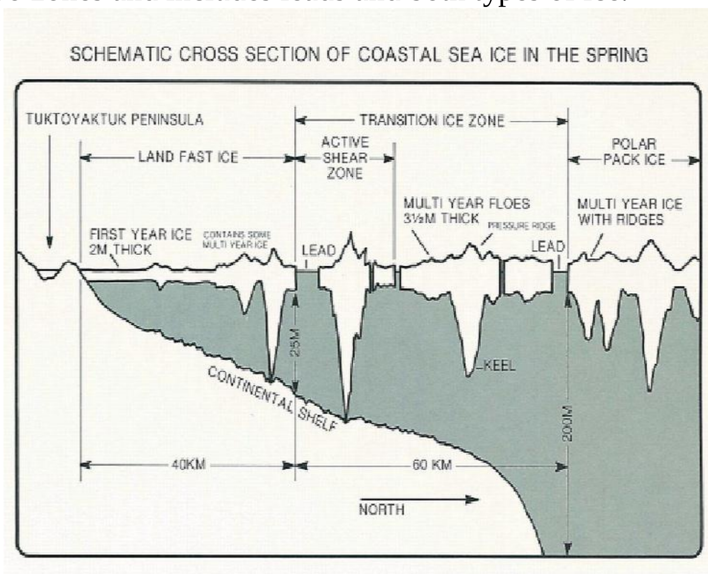


FIGURE 4 A cross section of the ice off the north coast of Canada

A cross section of the ice regime in the Arctic shows these three zones clearly.

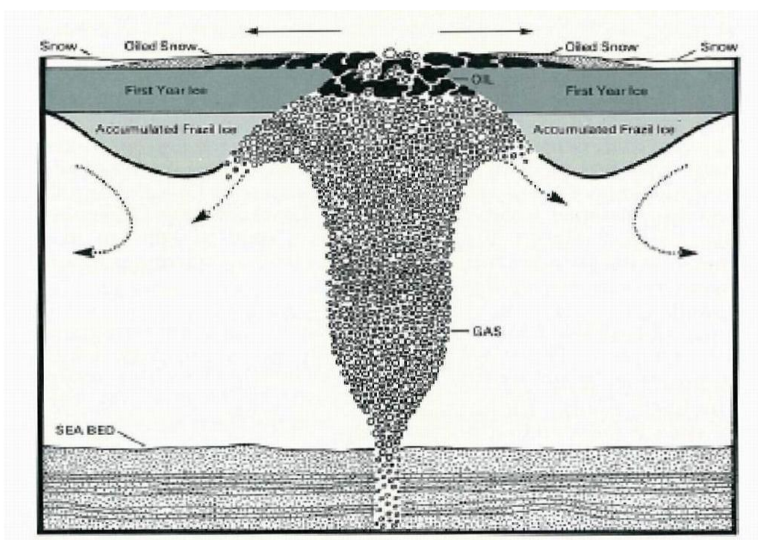


Figure 15: Blowout under first-year landfast ice.

FIGURE 5 Schematic of a blowout under ice

When a blowout occurs under ice a graphic view looks like this. There will be much gas with the oil mixed in creating a plume that rises and spreads under the ice and eventually breaks through to oil the surface. Oil will also be trapped in the ice since a blowout will occur during the drilling season and toward the end of the season the ice will be growing in thickness. The ice will also be moving past the site of the blowout if the drilling was being undertaken in the area of the polar pack or in the transition zone - both areas in Canadian Arctic waters identified for exploratory drilling.

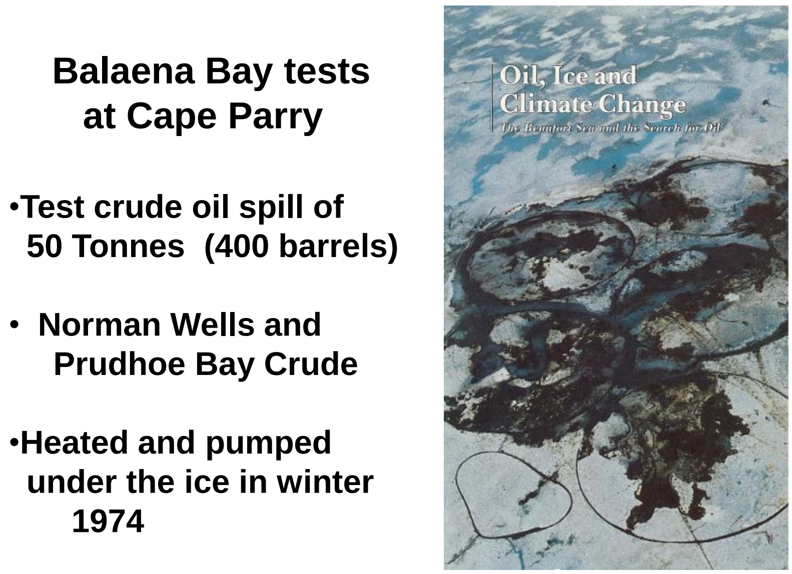


FIGURE 6

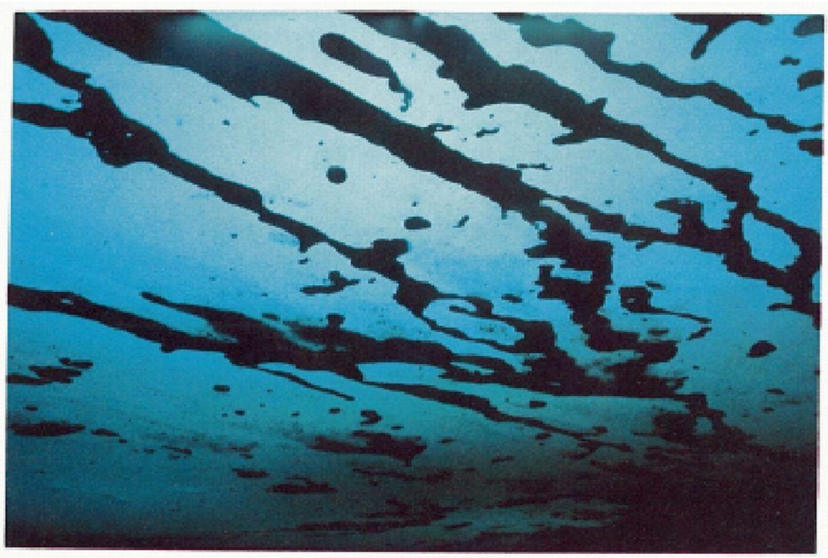
Experimental oil spill in the Arctic

The key experiment in these studies was an oil spill made in the winter of 1974 in which 400 barrels of heated crude oil were pumped under the shore fast ice into boomed off sections of a bay on Cape Parry. This test is still one of the largest ever conducted anywhere and the results should be studied with great care as plans are made for new drilling activities. This view shows the oil beginning to appear as the first year ice begins to melt in the spring. The ice at this time was 2 m thick.

One of the principal purposes of the Beaufort Sea Project was to determine whether oil spills and in particular a large blowout could impact the climate by modifying the sea ice regime as well as causing additional solar energy absorption by the darkening of the surface of the sea ice. My work was directly related to this aspect of the Study.

FIGURE 7

Oil on the surface looks like this and for the first few days contains all the components but under strong sunlight begins to evaporate the lighter compounds.



▲ Oil rivulets under first-year ice.

FIGURE 8

Oil rises in the water column and is trapped in cavities in the ice.

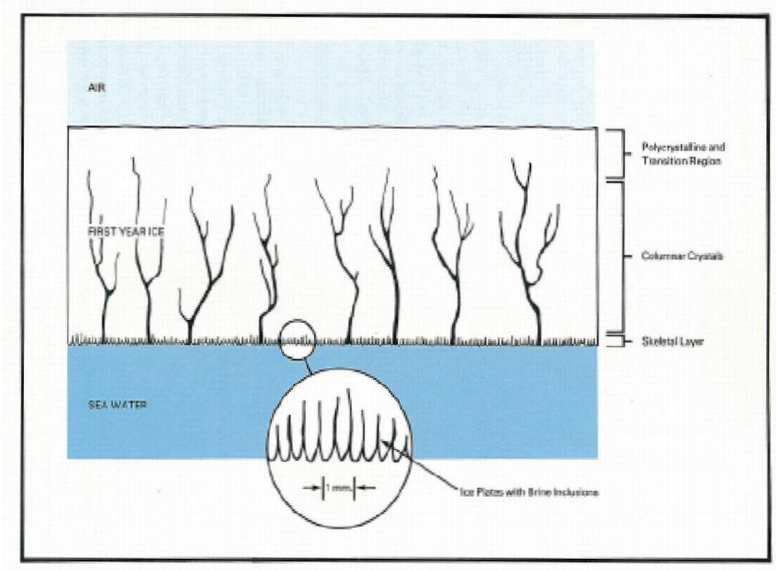


Figure 9 Diagram of brine channels in sea ice

Sea ice is a complex material and in the spring is full of brine channels where the salt has accumulated and then runs down into the water column. This is also where almost all primary productivity occurs as the spring sunlight stimulates the ecosystem of plankton and other micro-organisms and thus the whole food chain up to the whales and polar bears.

FIGURE 10
Appearance in the spring of oil in brine channels
on the surface of sea ice after a winter spill under the ice

The appearance of the ice with oil in brine channels is shown here indicating how difficult it is to separate the oil from the ice and how it coats the critical ice surfaces so important for the primary productivity of the food chain.

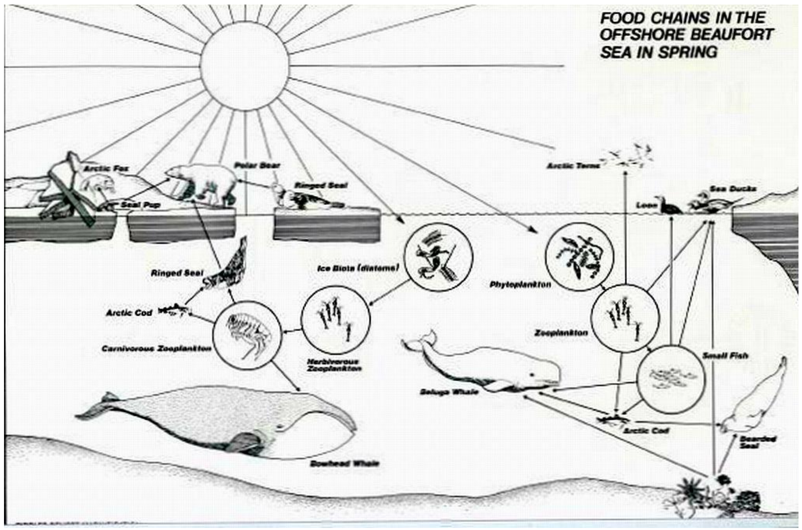


FIGURE 11 Web of life in the Arctic Ocean

The leads and the ice surfaces both under and within the sea ice are the sites and primary drivers for the food chain for all living things in the Arctic Ocean as can be seen in Figure 11. Oil introduced into this environment closes down the ecosystem.

FIGURE 12 Burning crude oil from sea ice in 1976

Crude oil can be burned on the surface of the ice if accelerants, such as gasoline, are used to ignite it. The black soot then greatly expands the area of contamination from the original spill site.

These important earlier studies will not be further reviewed in this presentation, but it is recommended that the summary reports and technical reports from the Beaufort Sea Project be consulted for additional details (2).

The National Energy Board (NEB)

The four figures below cover the National Energy Board (NEB) review of offshore drilling in the Arctic. The conclusion from having taken part in these hearings as an intervener, is that effective oil cleanup technology for spills in ice covered waters in the Arctic is non-existent. Much new research is required and significant investment in testing and trials will be needed if the requirements of the NEB as stated in their filing requirements document are to be met. The NEB published two reports on Dec 15, 2011 on the offshore drilling review: one on the review itself called 'Preparing for the Future" and the other "Filing Requirements for Offshore Drilling in the Canadian Arctic". Both are available from the NEB in Calgary or can be downloaded (3).

Figure 13 Points related to the NEB Review

National Energy Board review of offshore drilling in the Arctic

- Started early 2010
- April 20, 2010 BP blowout in the Gulf of Mexico
- Fact finding and information gathering
- Community meetings begin late 2010
- Roundtable in Inuvik Sept 2011
- Review Report published Dec 15, 2011
- Filing Requirements Report Dec 15, 2011

Figure 14 Testimony by an Inuit Elder at the NEB Review

Earlier offshore drilling in the 1970s and 1980s in the Beaufort Sea and High Arctic Islands (from John Amagoalik, Nunavut*)

- some oil and a lot of natural gas were found
- production was not economically feasible at the time
- Inuit organizations were not in place and very little information was passed to local people
- monitoring of the exploration was almost non-existent
- years later Inuit began to see the damage the oil companies had done in the High Arctic

* NEB Arctic Review report p 4

The NEB Review Process

- Information collected and put on NEB website
- Focus almost solely on northern communities
- Selective input from consultants
- Community interaction almost entirely with oil industry representatives; no independent scientists invited or supported to attend these meetings
- Final Inuvik roundtable tightly controlled with outside questions filtered through NEB HQ in Calgary and very limited support for independent advisors

NEB Conclusions related to Arctic Oil Spill Cleanup Technology

- Effective oil cleanup technology for ice covered waters is non-existent
- Lack of population and infrastructure in the remote Arctic is a huge challenge if a major spill occurs
- Logistics for a rapid response to a spill emergency are lacking due to long supply lines and weather and climate related impediments
- Never-the-less applicants are expected to apply "state-of-the –art" capacity for emergency response requirements for Arctic Offshore drilling

Figures 15 and 16 The NEB Review process and conclusions

Part 2 - Looking at current technology proposed for cleanup of oil spills in the ice covered Arctic Ocean – or – Can anyone clean up an Arctic oil spill?

When you review current industry capability for maritime oil spill cleanup and put it into an Arctic scenario, the situation does not look encouraging.

DRILL SHIPS IN ARCTIC ICE

a huge change for Native People

FIGURE 17 Drill ships in the Arctic

This picture illustrates the impact on the native culture of industrialization in the Arctic. Note the enormous difference in scale between the industrial activities and the hunter.

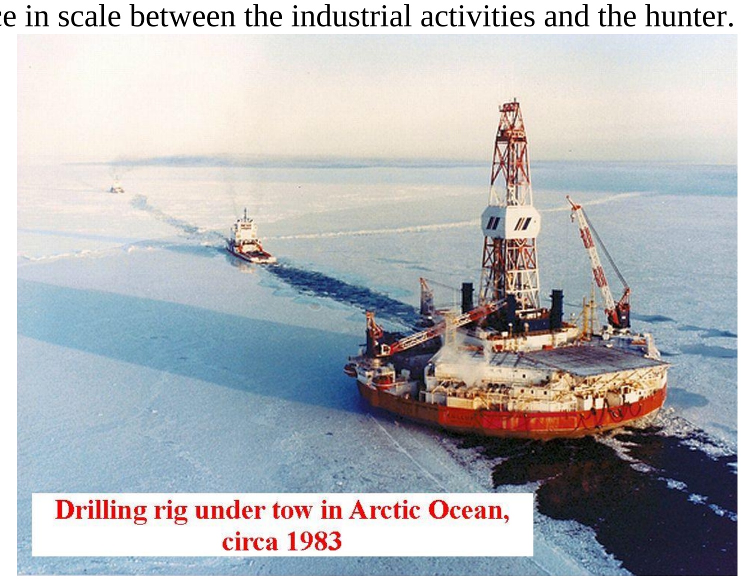


FIGURE 18 Drilling platform being moved through ice in an earlier period of oil exploration

The Prirazlomnaya offshore oil platform is shown being towed out to sea in northern Russia. This rig, the world's first drilling rig capable of operating in temperatures below –50 deg C, will enable Russia to start Arctic offshore oil production.

World's first -50 C drilling rig enabling Russia to start Arctic offshore oil production (2011)

FIGURE 19 Russian Arctic drilling platform in 2011

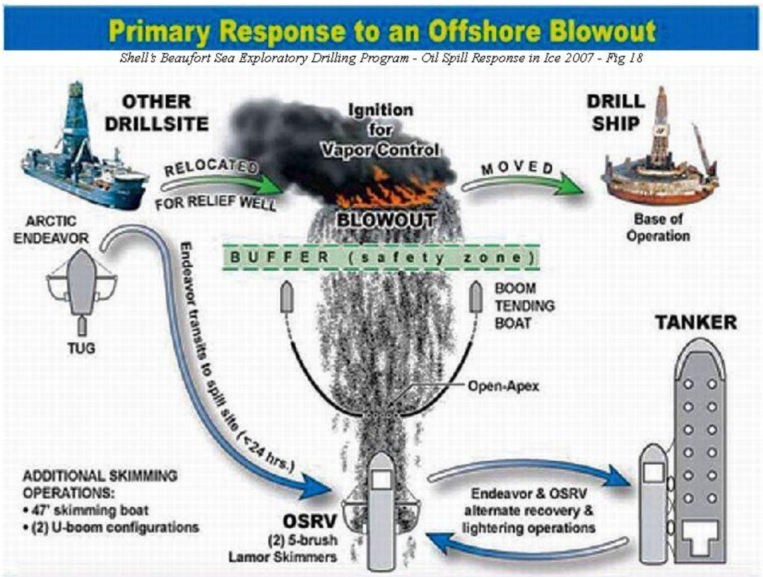


FIGURE 20 Shell Cleanup plan for offshore blowout (2007)

Shell, in a 2007 Beaufort Sea drilling program proposal (see Figure 20 above), provided an oil spill response plan. The drill ship moves off the blowout site which is ignited so that the gases and vapors are burned, a boom is deployed to funnel oil into skimmers that unload oil into a tanker while another drillship relocates to drill a relief well to block the blowout. This is the approach used in the Gulf of Mexico that was able to capture an estimated 3% of the oil from the blowout in 2010. The Gulf location was a few miles from the heart of the oil industry in the USA, there was no ice to contend with and the temperatures were warm rather than freezing. A fleet of tankers suitable for Arctic operations would be needed in the high Arctic to accept the oil/water mixtures from skimmers and take it south several thousands of kilometers to be treated. Is this feasible and will the ships be available?

Aside from drilling, there is an oil spill risk from tanker traffic associated with Arctic operations. A handbook is available from the International Tanker Owners Pollution Federation that has much valuable information related to oil spills (5). Some key points about the use of skimmers and booms, dispersants and burning are noted below.

ITOPF – International Tanker Owners Pollution Federation

- Pre-eminent in Ship-Source spill response
- In 40 years over 650 spills in 99 countries

See ITOPF 2011 Handbook – www.itopf.com

- Booms and Skimmers - Rare, even in ideal conditions for more 10-15% of the spilled oil to be recovered
- Dispersants potentially harmful if used incorrectly
- Residues from burning may sink, with potential long-term effects on sea bed ecology and fisheries.

FIGURE 21 Industrial Tanker association

The scale of marine oil spills and their locations is shown in the figure below. The Exxon Valdez spill in Alaska released 10.9 million gallons (250,000 barrels) of oil. This was less than 1/65th of that of the biggest spill on this map. The Gulf of Mexico BP blow out in 2010 released a total of 4.9 million barrels over five months and can be seen on the figure.

WORLD'S BIGGEST OIL SPILLS

EXXON VALDEZ not on this chart - Biggest spill was 65x greater

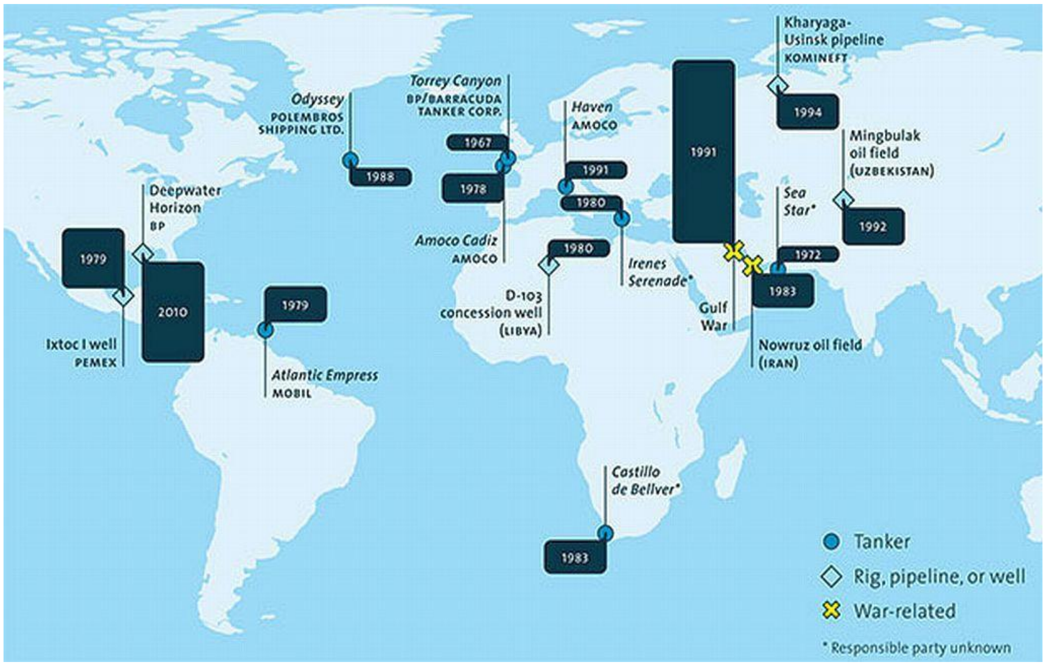


Figure 22 Taken from ITOPF Handbook 2011/12

A-WHALE for the Gulf Oil Spill

Converted 1100 ft Bulk Carrier

collect 500,000 barrels of oily water/day thru 12 horizontal slits

Figure 23 Oil spill cleanup in open water

MV ARCA Dutch Cleanup Vessel

during Prestige oil spill collected 5,000 tons of oil/day.
1 ton Oil = 7.3 bbl   5,000 ton/day = 36,500 bbl/day

FIGURE 24 Dutch oil spill cleanup vessel

The two Figures above show approaches used to collect spilled oil in the ocean in areas where there is no ice. Conditions shown are calm while often conditions are stormy with large waves. In the 2010 Gulf of Mexico spill, waves over 1.5 m (5 feet) required that oil spill cleanup operations be suspended a number of times.

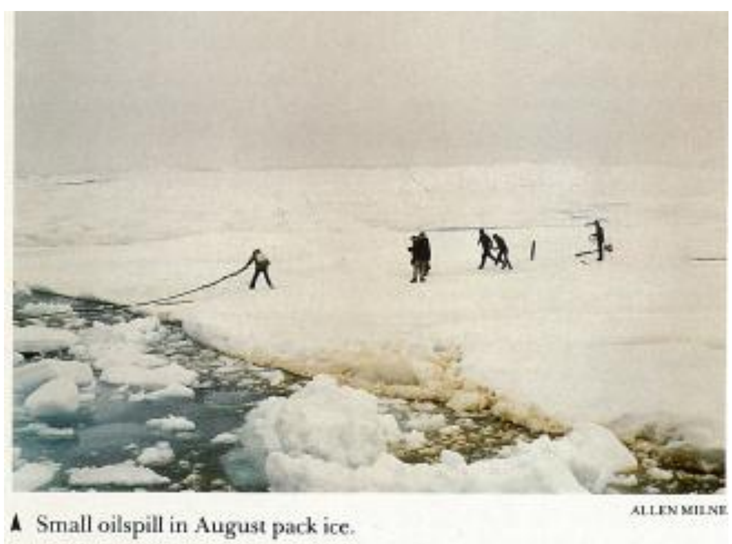


FIGURE 25 Arctic conditions in August for oil spill cleanup

Figure 25 shows a small Arctic Ocean spill being taken care of by six individuals in ice in August for comparison to open water oil spill cleanup techniques.

ITOPF – Boom in ice-infested waters

FIGURE 26 Oil booms in ice

Booms can be deployed in ice covered waters, but they are of limited effectiveness and are rapidly destroyed by the ice. Experience shows that booms in waves over 1m and currents over 0.35 mps do not work.

Alaska Beaufort Sea 2000
Exercise deploying booms - $400/metre

Figure 27 Laying booms in partially ice covered waters

Booms are expensive and difficult to deploy in icy waters and become useless in stormy conditions as mentioned above.

Small Oil Skimmer at work

FIGURE 28 Small oil skimmer deployed in calm ice containing waters

Various skimmers have been developed which work in calm conditions for small spills but would not be viable in open water with waves and with wind conditions beyond calm. They could help collect oil in leads under calm conditions.

GODAFOSS SPILL OSLOFJORD Feb 2011

FIGURES 29 – 33 showing cleanup operations in an oil spill in Norway (2011).

GODAFOSS cleanup - 2011 OsloFjord *Hindered by Icy Conditions*

Godafoss – multiple booms

Boom in ice – 2011 Norway GODAFOSS
OsloFjord

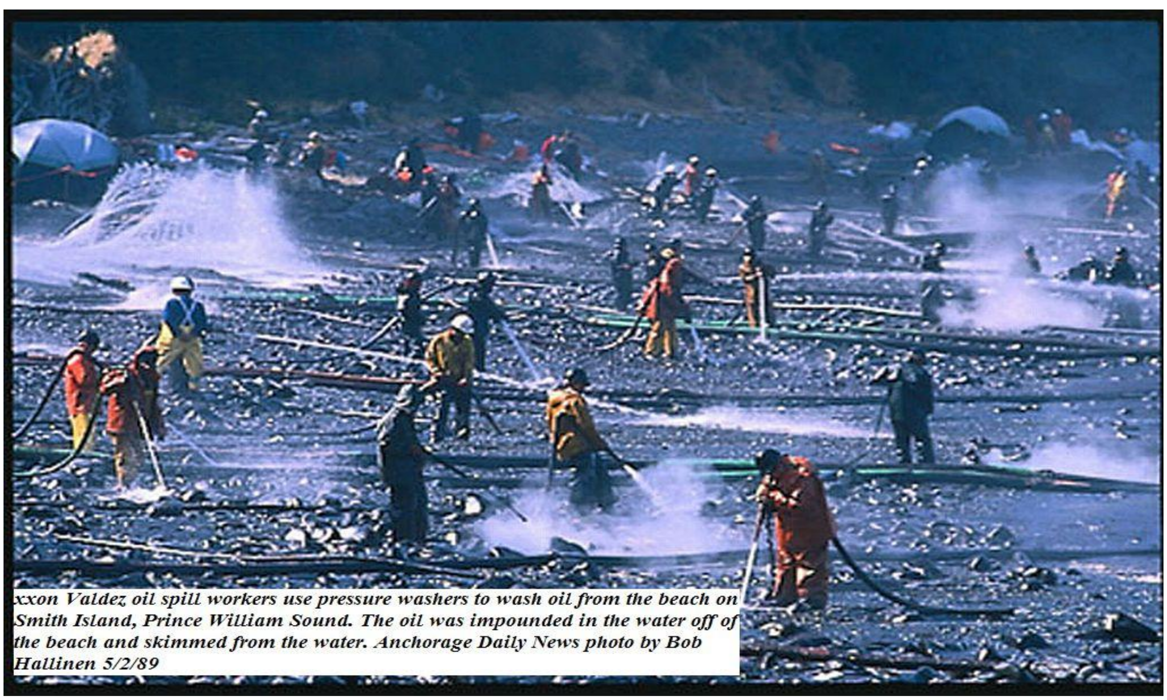
GODAFOSS partial boom deployment

FIGURES 29 – 33 showing cleanup operations in an oil spill in Norway (2011)

Cleanup operations on a spill in 2011 in Oslo Fjord in Norway in partially ice covered waters are shown here. This spill occurred close to a major city in a country that leads the world in drilling and offshore oil production in northern waters. They deployed booms but found that the icy conditions hindered the cleanup. Multiple booms were tried but it is clear that oil crossed over the booms (see Figures 31 and 32) and ice destroyed the booms in some cases (see figure 33).

Cleanup of rocky beach by hand

BEACH CLEANUP - Exxon Valdez pressure hoses + boom + belt skimmer



xxon Valdez oil spill workers use pressure washers to wash oil from the beach on Smith Island, Prince William Sound. The oil was impounded in the water off of the beach and skimmed from the water. Anchorage Daily News photo by Bob Hallinen 5/2/89

Aerial beach cleanup 1989
Prince William Sound Alaska

FIGURES 34 – 36 Cleaning oil from beaches in Alaska

Oil contaminated beaches with cleanup activities underway are shown in the above figures. They show the level of effort and number of workers needed. They also suggest the health impacts on the workers and the need for protective clothing and breathing masks. These photos show the situation in temperate locations where ice and snow and extreme cold are not factors. It is also clear that having the level of human effort (at the peak, 11,000 personnel, 1,400 vessels and 85 aircraft were involved in the cleanup) shown here, in the high Arctic, would be very difficult if not impossible. It is likely that Arctic beaches could never be cleaned. The oil spill from the Exxon Valdez has been very well analyzed (6). The oil moved rapidly from the initial release March 24th so that by the end of the month it was being found 90 miles away and ultimately was found almost 500 miles from the spill site. It contaminated 1300 miles of shoreline.

Controlled burn of Oil from GoM
What is Impact on Arctic Albedo?

Figure 37 Burning oil in the Gulf Of Mexico from the Deepwater Horizon well

How harmful is this to marine life?

FIGURES 38 Use of dispersants in the Gulf of Mexico spill in 2010

The July 12, 2011 SL Ross report for the NEB, *Spill Response Gap Study for the Canadian Beaufort Sea and the Canadian Davis Strait,* states on Page 15 that in-situ burning (ISB) is *not* possible in winds over 10 kts, and mechanical recovery and dispersants are *not* possible in winds over 15 kts. (7).

Figures 37 and 38 above, show burning off the oil in the Gulf blowout and the use of aerial spraying of dispersants also in the Gulf. Both of these methods of "cleanup" change the nature of the environmental impact but do not solve the problem. The best solution for a spill is to remove the oil from the environment quickly before it spreads. The final part of the presentation offers two possible methods for this approach to oil spill cleanup.

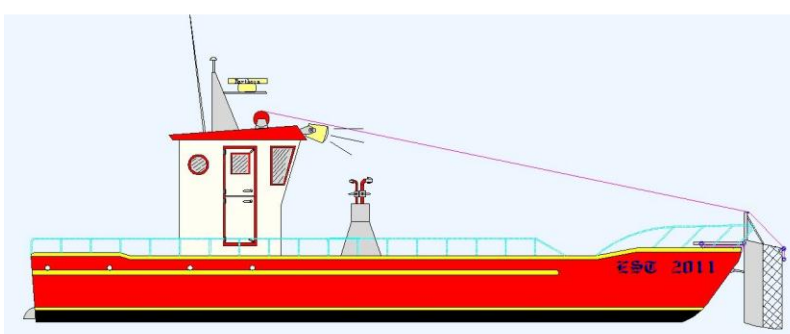
Part 3 - What are the R&D&D requirements (especially the final D for demonstration) leading to safe and low risk drilling off-shore in the Arctic?

From our review of oil spill cleanup technology, it is clear that considerable improvements must be made and could be achieved related to actual methods of removing the oil from the environment after a spill and in the logistics and management of the cleanup effort. One of the key points is to have adequate equipment and trained people readily available to act quickly when the spill is first detected. In order to accomplish this in the Arctic, there will have to be serious and well funded R&D accompanied by demonstrations and tests of the approach with actual oil spills similar to the ones earlier described in the Beaufort Sea Project in the 1970s. The lack of real tests in the environment due to concerns with damage to the areas where the tests are conducted should be weighed against the prospects of the enormous risk of assuming that field tests with stimulant oils or virtual simulation tests will reflect the real situation.

Finally, the equipment must be positioned close to the probable location of Arctic oil spills and the closest local population trained to respond and kept prepared by regular training exercises. Backup workers and equipment must also be available within a day or so. Equipment and workers could be delivered by air from a central Arctic location where significant cleanup equipment could be kept in readiness. Canada is currently boosting its Arctic research capabilities and the Department of National Defence is also enhancing Arctic capabilities and improving Arctic infrastructure; both are initiatives which could be harnessed to improve Arctic oil spill response capabilities.

New 12 metre EST* skimmer

being built for Canadian Coast Guard



Extreme Spill Technology Inc. see www.spilltechnology.com

FIGURE 42 A new Canadian approach to oil spill cleanup

EST Skimmer – operation

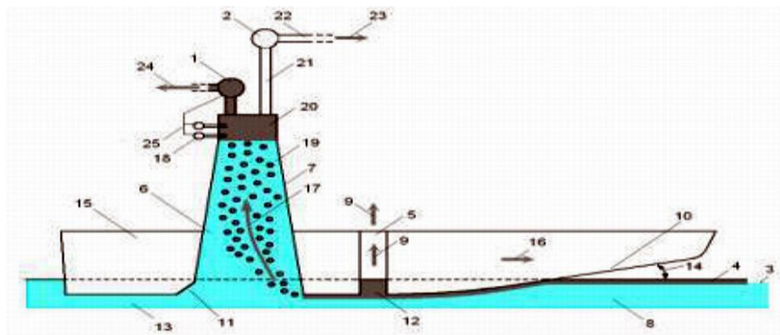
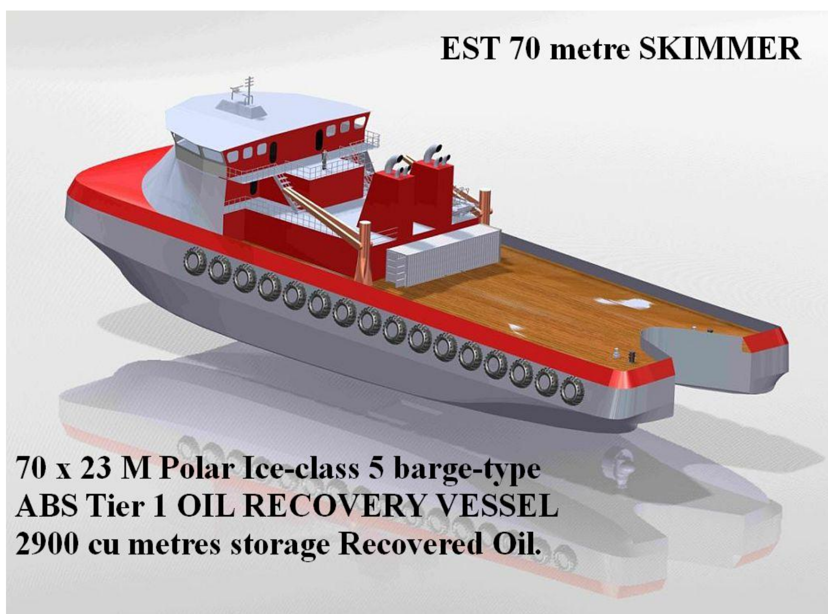


Figure 43 Gravity separation method of oil recovery in EST oil cleanup vessels



FIGURES 44 Proposed Polar class oil cleanup vessel

The figures above show a Canadian oil spill cleanup technology which is being tested by the Canadian Coast Guard. The company, Extreme Spill Technology Inc. (8), has currently some smaller vessels being built in China. The method of oil removal from the water is simple and effective compared to other skimmer designs and waves would be less of a problem for this type of skimmer. Tests are needed in ice covered waters to see what designs would best operate in the Arctic. Ice breaking capacity would also be required in most cases when an ice cover is present at the time of the spill and vessels capable of transporting the collected oil and water would be required.

There are also new materials that can be used to coagulate and render non-toxic spilled oil which are now being marketed in Canada. For example the products of the company Spill Green Inc. which demonstrated the cleanup capability of their material with used motor oil in an ice water mixture at the RESTCO Forum held in Ottawa in September (9).

CONCLUSIONS

There are four recommendations:

1. A quick response to avoid the oil becoming widely dispersed and impossible to collect which is critical if the spill occurs under moving ice. Logistics issues are key to successful spill remediation in the Arctic where pre-positioning of spill cleanup assets is a necessity.

2. New technology is required and a potential effective skimmer is being tested and more ice coping effective approaches are needed with field testing part of the process.

3. Do not burn the oil due to the impact of soot and do not use dispersants which are toxic themselves and can transfer the oil from the surface where it could be collected and into other regions of the water column or to the bottom with serious and at present uncertain consequences.

4. Use non-toxic coagulants for smaller spills such as the product Spill Green (see www.spillgreen.com)

REFERENCES

1. A. F. Treshnikov, Chapter 6 in "Assessment of the Arctic Marine Environment: Selected Topics", Institute of Marine Science, Univ. of Alaska, Fairbanks (1976).

2. Beaufort Sea Project Summary Report reprints see http://www.restco.ca/BSP_Reprints.shtml

3. National Energy Board Reports on the Review of Offshore Drilling in the Arctic see http://www.neb-one.gc.ca/fetch.asp?language=E&ID=A37753

4. See http://www.cbc.ca/news/business/story/2011/09/12/north-national-energy-board-roundtable-offshore-oil.html

5. ITOPF Handbook 2011/12 see www.itopf.com for information and to request a copy. ITOPF also is a source of many technical publications related to oil spills.

6. For an excellent review of the 1989 Exxon Valdez oil spill see http://www.eoearth.org/article/Exxon_Valdez_oil_spill taken from the Encyclopedia of Earth first published (2010).

7. SL Ross Report to the National Energy Board, "Spill response gap study for the Canadian Beaufort Sea and the Canadian Davis Strait". July 12, (2011).

8. Extreme Spill Technology see www.spilltechnology.com

9. For Spill Green product information see www.spillgreen.com and for the test of the product see http://www.restco.ca/Inuvik_RT_Ottawa_Presentations.shtml for the Spill Green presentation on Sept 13, 2011.

Documents Referenced in the Advance Questions Submission to the NEB by RESTCO and of general value in oil spill remediation follow

The ITOPF 2011 handbook (PDF 3.3 MB) (54 pp)

The Macondo Blowout Environmental Report January 2011 (PDF 2.5 MB) (9 pp)

The Captain Mark Turner report on Newfoundland Labrador offshore oil spill prevention and response capabilities December 2010 (PDF 4 MB) (273 pp)

The SL Ross Report - Spill Response Gap Study for the Canadian Beaufort Sea and the Canadian Beaufort Sea and Davis Strait July 2011 (PDF 111 KB) (37 pp)

The PEW report - Oil Spill Prevention and Response in the U.S. Arctic Ocean: Unexamined Risks, Unacceptable Consequences
Summary November 2010 (HTML)
Full Report November 2010 (PDF 7.9 MB) (146 pp)

The NUKA report - Oil Spill Response Mechanical Recovery Systems for Ice Infested Waters: Examination of Technologies for the Alaska Beaufort Sea. June 2007 (PDF 2.7 MB) (100 pp)

The WWF report "Lessons not learned: 20 Years after the Exxon Valdez Disaster - Little Has Changed in How We Respond to Oil Spills in the Arctic" Feb 2009 (PDF 1.1 MB) (16 pp)

COSTCO BUSAN Oil Spill in San Francisco Bay November 2007 (video 1 minute)

Alaskan oil boom 2000 tests "What If An Oil Spill Happened in the Arctic?" July 2011 (video 2 minutes)

The 26 minute video video recapping BP's Gulf Gusher's effects August 2011 (HTML & video)

Additional Background Documents

The Beaufort Sea Project Reports

Western Arctic Oil Spill Response Gaps - World Wildlife Fund Canada - March 2011 (PDF 1.8 MB) (28 pp)

CBC Doc Zone - Blowout - Is Canada Next.2010.12.09 (video) 44 minutes

Overview of Historical Canadian Beaufort Sea Information - February 2009 (PDF 2.5 MB) (99 pp)

History of petroleum industry in Canada (PDF 1.7 MB) (14 pp)

LAB EXERCISE: 3 Spill Tools: An Oil Spill Response Exercise
http://www.eoearth.org/resources/view/166779/?topic=50365
To evaluate three approaches - dispersant - burning – skimmers

Getting Spill Tools - Each Spill Tool can be downloaded from the Web at
http://response.restoration.noaa.gov/spilltools
For additional information: http://response.restoration.noaa.gov
orr.spilltools@noaa.gov - (206) 526-6317

North Slope Borough Oil Spill Mitigation, a paper by Extreme Spill Technology Inc., see www.spilltechnology.com to download a copy.