Advances from Arctic Oil Spill Response Research

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Over the past four decades, the oil and gas industry has made significant advances in being able to detect, contain and clean up spills and mitigate the residual consequences in Arctic environments. Many of these advances were achieved through collaborative research programs involving industry, academic and government partners. The Arctic Oil Spill Response Technology - Joint Industry Programme (JIP), was launched in 2012 and completed in early 2017 with the objectives of building on an already extensive knowledge base to further improve Arctic spill response capabilities and better understand the environmental issues involved in selecting and implementing the most effective response strategies.

The JIP was a collaboration of nine oil and gas companies (BP, Chevron, ConocoPhillips, Eni, ExxonMobil, North Caspian Operating Company, Shell, Statoil, and Total) and focused on six key areas of oil spill response: dispersants; environmental effects; trajectory modeling; remote sensing; mechanical recovery and in-situ burning. The JIP provided a vehicle for sharing knowledge among the participants and international research institutions and disseminating information to regulators, the public and stakeholders. The network of engaged scientists and government agencies increased opportunities to develop and test oil spill response technologies while raising awareness of industry efforts to advance the existing capabilities in Arctic oil spill response.

The JIP consisted of two phases, the first included technical assessments and state of knowledge reviews resulting in a library of sixteen documents available on the JIP website. The majority of the JIP efforts focused on Phase 2, actual experiments, and included laboratory, small and medium scale tank tests, and field research experiments. Three large-scale field tests were conducted in the winter and spring months of 2014-2016 including recent participation of the JIP in the 2016 NOFO oil on water exercise off Norway.

The JIP was the largest pan-industry programme dedicated to oil spill response in the Arctic, ever carried out. Twenty seven research projects were successfully and safely conducted by the world's foremost experts on oil spill response from across industry, academia, and independent scientific institutions in ten countries. The overarching goal of the research was to address the differing aspects involved in oil spill response, including the methods used, and their applicability to the Arctic's unique conditions. All research projects were conducted using established protocols and proven scientific technologies, some of which were especially adjusted for ice conditions. This paper describes the scope of the research conducted, results, and key findings. The JIP is committed to full transparency in disseminating the results through peer reviewed journal articles, and all JIP research reports are available free of charge at www.arcticresponsetechnology.org.

Introduction

A key characteristic that distinguishes much of the Arctic from other oil and gas exploration and production areas is the presence of ice for all or part of the year, extreme cold and extended periods of darkness. Ice cover, where present, can vary considerably across Arctic regions and sub regions, depending on the season and location. Selection of response strategies depend upon a variety of factors: the size and type of spill; local weather and sea conditions; the presence, concentration and characteristics of ice; and the relative risks to response personnel and to the marine and shoreline environments. Rapid and effective response can be achieved with the aid of a Net Environmental Benefit Analysis (NEBA), to determine the most effective strategies to minimise the impact of a spill for any given scenario. The flexibility to use a broad range of cleanup options, as conditions change, is essential to mounting an effective response.

Dispersants

Dispersion of oil can be an effective way to enhance the natural biodegradation process to remove spilled oil from the marine environment. Research over several decades has shown that dispersants can be as effective in near-freezing waters as they are in temperate waters, when properly applied. The use of dispersants can provide an oil spill response option with a high encounter rate, high effectiveness and greater responder safety than mechanical response or ISB. A new approach for the use of dispersants – dispersant injection for subsea releases following well control events – provides an additional tool that enhances contingency planning for offshore operations. In many cases, including in the Arctic, dispersants could be the best response option to treat an oil spill before it has spread, broken apart, impacted marine mammals and birds, or stranded in sensitive environments.

The JIP conducted two projects designed to further enhance the industry's understanding of dispersant efficacy in ice. The objective of the first project was to develop a numerical model that predicts the potential for a dispersed oil plume to resurface and reform as new slick under the ice. Phase one of the project, provided the state of knowledge concerning under-ice turbulence and available methods for obtaining additional data needed to develop a reliable model to predict the potential for oil resurfacing, within a two-day period, based upon an initial oil droplet size distribution.

Phase two research included modelling studies, flume tank turbulence experiments, and under ice turbulence and dye study field experiments at Svea, Svalbard, Norway in 2015/2016 that were used to develop a matrix table to predict how long oil is expected to remain dispersed. The overall goal of the second project was to optimize response strategies and build confidence in using dispersant in ice-covered waters. Researchers have previously examined dispersant effectiveness in cold waters with sea ice, at laboratory scale, in wave basin tests, and at sea using a variety of oils. It has been demonstrated that dispersants can generally be more than 80 percent effective in near-freezing waters. The primary objective defined the operational limits of dispersant and mineral fines in Arctic marine waters with respect to oil type, oil viscosity, ice cover (type and concentration), air temperatures, and mixing energy (natural, water jet and propeller wash).

Mesoscale flume tank experiments established boundaries for dispersant efficiency with natural mixing energy, with propeller wash, in both ice and open water conditions. Five crude oils Alaska North Slope (ANS), Grane, Troll Blend, and Oseberg Blend, bunker oil and three commercial dispersants (Corexit 9500, Dasic NS, and OSR-52) were used with two levels of ice coverage (50% and 80%), and three salinity levels (5, 15, and 35 ppt). Key findings are:

- The effect of ice did not influence the results significantly, but water salinity did, with the poorest dispersant efficiencies found for the 5 ppt salinity water.
- Dispersant effectiveness varied with both oil type and dispersant type applied, and the effectiveness increased when higher mixing energy conditions were used.

The JIP also evaluated the strategy of injecting dispersants during subsea releases. The study used the SINTEF Oil Spill Contingency and Response (OSCAR) model with improved algorithms for droplet size predictions. In total, the model simulation runs covered 30 different subsea releases of oil and gas mixtures with varying release depths (up to 1,000 m), three different wind speeds and with/without subsea dispersant injection (SSDI). Key findings are:

- The simulations indicated that SSDI could be a very effective response method, especially when taking into account the significantly reduced persistence and surface signature of the resulting thinner oil slicks.
- There is a notable difference in the surface slick formed for a release treated with SSDI compared to a non-treated release. SSDI results in both less oil and wider/thinner oil slicks on the surface compared to oil alone scenarios. These thinner, non-emulsifying surface oil slicks are expected to have very short life time due to enhanced natural dispersion.

Environmental Impacts from Arctic Oil Spills and Oil Spill Response Technologies

The overall goal of this research project was to improve the knowledge base for using "Net Environmental Benefit Analysis" (NEBA) in oil spill response decision making. To meet this objective the JIP commissioned five projects.

The first identified 960 literature references from investigations into spilled oil and oil spill response technologies in the Arctic marine environment and culminated in the online publication of a report “Environmental Effects of Spilled Oil and Response Technologies in the Arctic” (Word 2014) . The report is the first unified compilation of the significant body of research on this area, confirming that a large amount of literature is already available to aid informed oil spill response decision-making in the Arctic. Key findings are:

- There is an existing science base for Arctic NEBAs. Many baseline ecosystem and biodiversity assessments exist to help us better understand and protect the marine Arctic environment. Extensive data sets on oil fate and effects and spill response techniques are available from field and laboratory studies representing the different seasonal conditions and environments in the Arctic.
- Biological organisms tend to aggregate at interfaces like the water/ice interface, which is one of the unique features of the Arctic ecosystem. Undispersed oil might collect at this interface, potentially interfering with unique Arctic biota. The review recommended acquiring information on the potential effects of oil on these Arctic communities to better assess possible impacts in NEBA.

Recommendations from the phase one review led to four additional research projects aimed at enhancing data access to NEBA practitioners, and reducing remaining uncertainties surrounding the sensitivity and resiliency of sea ice communities to oil frozen into the upper layer of the ice sheet.

The first project developed a NEBA support tool that identifies and summarizes crucial data for evaluating the ecological consequences of oil spill response options. The project collected and organized nearly 3,500 documents from the scientific, research and government literature describing the consequences of spilled oil in the Arctic environment. These documents, along with several other related data sources, form the basis of the current searchable publicly available NEBA website http://neba.arcticresponsetechnology.org

Field experiments, approved by the Governor of Svalbard, used mesocosms installed through the ice (a mesocosm is any outdoor experimental system that examines the natural environment under controlled conditions. In this way mesocosm studies provide a link between field surveys and highly controlled laboratory experiments). A multidisciplinary team of world class experts examined the long-term fate, behaviour, persistence and biodegradation of the oil in ice together with the impacts on the microbial and plankton communities in and under ice, following exposure to oil remaining in the environment after different response scenarios.

Eight mesocosms installed in the sea ice of Van Mijen Fjord, Svea, Norway in January 2015, remained in place until July 2015. Two mesocosms contained oil only, to represent natural attenuation; two contained oil mixed with dispersant (but remaining in an undispersed state); two contained burn residues representing the after effects of an in situ burn response, and the two remaining mesocoms served as controls (no oil). The field experiments spanned a single winter and spring season including the period of peak biological activity. The five month study period included measurements of the following parameters in the water column, through the ice layer and at the water-ice interface: chemical composition of the oil, bacterial populations and oil degrading microorganisms, microbial activity and biodegradation activity, zooplankton - survival, feeding and reproduction (under ice), and ice algae primary production.

Preliminary results and findings from the field experiments suggest that:

- Arctic bacterial populations are dominated by a few species
- Oil degrading organisms are more abundant in the oil contaminated ice samples than in the controls, particularly with the addition of dispersant to the oil
- Hydrocarbon levels in the water under the ice appear to be close to background level when oil, oil and dispersants or remains of burned oil get encapsulated in ice, and

- The trace hydrocarbon level measured under the ice will have a limited effect on zooplankton reproduction.

Oil Spill Detection and Mapping in Low Visibility and Ice

To mount an effective response using mechanical recovery, dispersants, or ISB, it is critical to know where spilled oil is at any given time, and be able to define the boundaries of the contaminated area. Ideally, any surveillance program will also provide some indication of the distribution of oil thickness or at least identify the thickest patches.

The JIP conducted projects separated into three distinct phases to assess and improve industry's remote sensing and monitoring capabilities in darkness and low visibility, for oil on the ice surface, on the water between floes, and trapped underneath or within the ice. Phase 1 provided technical assessments of existing and emerging surface and subsea remote sensing technologies. Key findings are:

- Industry has a range of proven airborne and surface imaging systems operated from helicopters, (satellites??) fixed-wing aircraft, vessels, drilling platforms and in some cases the ice surface itself. While developed and used operationally for open water scenarios, many of these sensors have varying degrees of potential for oil detection and mapping in a range of ice conditions.
- At present, there is no proven airborne sensor that can reliably detect oil trapped within the ice.
- Autonomous underwater vehicles (AUVs) have successfully operated in ice-covered waters over the past decade or more and are now a viable platform to conduct reliable long-range under sea ice operations with upward looking sensors.

- Sensors such as sonar mounted on AUVs, may have the ability to detect oil encapsulated within the ice to a certain extent (limited by the thickness of new ice grown beneath the oil layer)
- Based on these assessments, a Phase 2 test program was developed to further evaluate and qualify the most promising sensors and platforms and recommend the most effective sensor suite for detecting oil in the ice environment. Research experiments at the U.S. Army Corps of Engineers-Cold Regions Research and Engineering Laboratory (CRREL), Hanover, New Hampshire, evaluated the performance of various surface and subsea remote sensing technologies. Sensor testing began in November 2014 and spanned a two-month ice growth phase, ending with an 80 centimetre thick sheet of level salt-water ice and followed with a one-month decay/melt period. Sixteen oil containment hoops were frozen into the ice. At predetermined stages, Alaska North Slope (ANS) crude oil at 0°C was injected into each hoop from below. A weekly transect was made both above and below the ice to allow sensors to collect data along the length of the ice sheet with oil layers at different depths within the ice.

Above-ice sensors were mounted on a long boom above the ice and included: a frequency modulated continuous wave (FMCW) radar, ground penetrating radars (GPR) operating at two frequencies, visible and infrared cameras, and laser fluorescence polarization (FP) sensor. GPR and optical measurements were also collected at the ice surface.

Below-ice sensors were mounted on a trolley running on rails mounted on the tank bottom and included: spectral radiance and irradiance sensors, FP sensors, optical cameras, broadband acoustics (3 frequency bands), narrowband acoustics (4 frequencies), and multibeam acoustics (3 sensors).

The CRREL test program was the first time that an array of above-surface and subsea sensors was deployed under controlled conditions with simultaneous multi-sensor data collected from the initial growth of sea ice through to its final melt. Key findings from the project are:

- The project confirms the overall conclusion of previous work including Phase 1 and earlier JIPs, that no one sensor has the capability of detecting oil in all situations. Rather, some sensors may complement each other in terms of oil thickness resolution vs. area coverage or swath width. Future operational systems should consider suites of different sensors operating from various platforms under, on and above the ice surface to provide the means to detect oil in a range of ice environments at different times of the year.
- The study suggests that an effective underwater detection suite should have a low light camera, broadband and/or multibeam sonar, and possibly a spectral radiometer or FP. While the various sonar units had similar levels of performance, the multibeam sonar provides the added ability to create a 3D map of the underside of the ice that may help identify priority locations for oil to accumulate and narrow the search area (oil will naturally seek the highest spots in the under ice surface – thinnest ice).
- The study results suggest that aerial sensors should include visible and thermal infrared imagers. Existing commercially available GPR is capable of aerial mapping of oil on the ice surface under snow. Extending this capability to oil encapsulated within the ice sheet will require further development and testing of evolving technologies such as FMCW.
- GPR operating from the ice surface is an appropriate tool for detecting both oil under snow and trapped within the ice as long as there is a stable and safe working environment and the ice sheet is relatively cold (i.e. not during melt).

Phase 3 encompassed three new projects, two as follow-up to the previous Phase and one as a means of presenting the available knowledge base in an easy to use operational tool:

1. Further testing of mid and long wave infrared (IR) sensors to confirm their capabilities in a natural outdoors environment, not possible to replicate in Phase 2 with an indoor basin.
2. Further testing of an improved version of the FMCW prototype tested in Phase 2 with inconclusive results.
3. An operational guide that synthesizes the existing knowledge base on oil in ice remote sensing. The aim is to provide a concise operationally-oriented tool that responders can use to select the most effective sensors and platforms for a given set of conditions. The guide uses effective graphic design in illustrating sensor expected sensor performance with a range of different oil/ice categories.

In Situ Burning of Oil in Ice-Affected Waters

ISB is an oil spill response option particularly suited to remote, ice-covered waters. Thick oil slicks are the key to effective ISB. In high ice concentrations the close proximity of individual floes can limit oil spreading and keep slicks thick enough to burn. However, in open drift ice conditions and open water, oil spills can rapidly spread and become too thin to ignite. Fire-resistant booms that can collect and thicken slicks in open water can be impeded by the presence of even minimal ice cover.

The overall goal of this project was to ensure that ISB is available to industry as a response option. This requires ISB to be incorporated into contingency planning and that response organisations have the necessary resources and training. The project developed a series of educational materials aimed at informing industry, regulators and external stakeholders about the significant body of knowledge that currently exists on all aspects of ISB: operational, environmental, and scientific.

Three comprehensive state of knowledge reports were developed and are available on the JIP website. The first covers the roles, functionality, benefits and limitations of ISB as a response option in the Arctic offshore environment including planning and operational aspects and any potential impacts on human health and the environment; the second reviews the findings of all relevant scientific studies and experiments as well as previous research efforts on the use of ISB in Arctic environments both offshore and onshore; the third summarizes the regulatory requirements needed to obtain approval for use of ISB in Arctic nations.

Herders and In Situ Burning:

Researchers have studied the use of herders in oil spill response since the 1970s. Extensive laboratory and field research over the past ten years has focused on the use of herders as an aid to ISB operations, primarily in open drift ice or calmer open water conditions. The use of herders on an oil slick does not detract from the effectiveness of subsequent or concurrent chemical dispersant application or mechanical recovery. The use of herding agents in conjunction with ISB became a central focus on the JIP work on burning. A number of projects included laboratory and large test basin experiments, as well as controlled releases in the field. These are described below.

In 2014/2015 SL Ross Environmental Research Ltd., the Danish Centre for Environment and Energy, and the Danish Technical University jointly conducted a research project for the JIP aimed at defining the fate and environmental effects of herders in Arctic waters and the windows-of-opportunity for herder use in cold open water and loose drift-ice conditions. Small-scale laboratory experiments in the SL Ross laboratory and meso-scale experiments at CRREL were conducted to assess the window of opportunity for two commercially available herders (ThickSlick 6535 and OP 40) with four different crude oils. Key findings are:

- The initial herded thickness achieved is a function of herder and crude type and weathering
- OP-40 (a newer silicone-based herder) was generally better than the traditional ThickSlick 6535
- As the crude oils evaporated, in general the herders became more effective, except when the evaporation caused the oil's pour point to increase to more than 8° to 10°C above the ambient temperature: at that stage neither herder could contract the oil
- Herders could contract lightly emulsified oil (25% water content), but not moderately emulsified oil (50% water)
- Low concentrations of slush ice on the water did not detract from the performance of the herders; but, the presence of high concentrations of slush ice prevents the herders from reaching the edge of the slick (and prevents the oil itself from spreading)
- Gentle, non-breaking wave action appears to assist with herding

The fate and environmental effects experiments in Denmark involved the same two herders and two of the oils tested previously at SL Ross; ANS and Grane crude oils (fresh and emulsified). To summarize these results:

- Most of the herder around an oil slick remains on the water as a very thin molecular monolayer after the slick is burned in situ

- Very low concentrations (parts per billion) of herder are detected in the water under the slick. These levels are several orders of magnitude less than the concentrations necessary to cause toxicity in lab tests. Herders are intrinsically non-soluble in water.
- No detectable levels of herding agents were found in the smoke plume
- In theory, herders present in relatively thick layers could affect seabird feathers by altering their water repellence, as observed with oil slicks and burn residue. However, in practice the very small dosages of herder applied around an oil slick spread almost instantaneously into an extremely thin film. Consequently there is no opportunity of significant impacts in a "real world" application. Herder monolayers will not persist on the water surface as they disperse very easily. In addition, the activities involved in oil response (helicopters and vessels) would deter waterfowl from landing while herders are applied.

Herder and In Situ Burn (ISB) field research experiments conducted at Poker Flat, Alaska

The Alaskan tests were a joint venture between the University of Alaska Fairbanks (UAF) and the JIP to validate the use of herders in combination with ISB when both are applied by helicopter. The goal was to prove the concept of a rapid response herder/burn aerial system to enhance responders' ability to use ISB in drift ice conditions. The JIP selected the Poker Flat Research Range, managed by the UAF as an ideal site to build a large temporary test basin of 8,100 square meters. Key criteria were: remote location away from populated areas, expansive flat space without obstructions, road access and low wind speeds.

Five separate experiments were conducted in April 2015 that utilized herding agents followed by in situ burning. Each experiment used 75 or 150 litres of ANS crude oil. Two herders, OP-40 and Thickslick 3565 were tested and applied with a prototype herder application system (internal tank and hose reel) mounted on a Bell 407 helicopter. Once the herder was applied, the helicopter landed and picked up a Helitorch™ for the ignition phase approximately 10-15 minutes later. Additional testing both at Poker Flat and in Ottawa, Canada successfully used a robotic helicopter to apply herder and subsequently ignite a small test slick. Key findings from the experiments are:

- Successful validation that herders can be applied to free-floating oil slicks from a helicopter and subsequently ignited.
- Both OP-40 and ThickSlick 6535 were effective in controlling the thickness of the floating oil spill and are equally effective in fresh water and salt water.
- Need to develop an integrated herder/igniter system that performs both operations in a single flight.
- Robotic helicopters are capable of delivering both herder and ignitor but require further development and improvements to reliability and capacity.

Development of an Integrated Herder Delivery and Ignition System

Based on recommendations and experience from the experiments conducted at Poker Flat, AK the JIP commissioned a project to develop an integrated herder delivery and ignition system that will enable both functions in one flight without landing or hovering to pick up another tool. A launcher capable of ejecting up to 15 igniter cartridges was integrated into the existing airborne herder application system (tank, pump, hose reel and spray nozzle) used in the Alaska tests. The cartridge launcher was live-ground tested on actual crude oil spills in an outdoor basin at the CRREL facility in December 2016 and then installed as an integrated package with the herder spray system in a Bell 407 helicopter and tested for airworthiness in January 2017   The system is now available as an operational prototype for use on an accidental spill as needed. With aerial application of both the herding agent and ignition source (igniter), the herder/burn combination becomes an extremely rapid and effective new response tool, independent from vessel support.

Development of Long Range Aerial Ignition System

To date, the effectiveness of in situ burning operations at remote locations offshore has been restricted by logistical limitations. Handheld ignitors require a stable ice cover for work crews to access the oil or small boats deployed from support vessels. The under slung Helitorch™ greatly slows the helicopter and results in a limited radius of operation. In addition, the standard Helitorch™ tank capacity is not sufficient to treat a significant area of oiled ice as could occur with oil rising to the surface in the spring. There is a need for an ignition system that can deliver larger payloads of gelled fuel, hundreds of miles from a support airport or offshore facility. Building on earlier ground-based tests in Alaska, a new engineering study produced a conceptual design of a palletized airborne ignition system capable of rapid installation in a Casa 212 airplane or S-92 helicopter. Both aircraft have the payload capacity to handle a 300 gallon gel fuel tank and a rear ramp to accommodate a trailing hose and nozzle to eject and ignite the gelled fuel deployed as fuel globules.

Herder Research Conducted During (NOFO) June 2016 Oil on Water Field Exercise

The goal of this project was to validate the findings of an earlier field study in the Norwegian Barents Sea (2009) where a herded slick was successfully burned in an opening within pack ice. The primary objective of the new field research was to validate the use of herders in open water conditions. A secondary objective was to see if the presence of herders on the water surface could reduce the number of breaking waves and expand the ISB window of opportunity.

The JIP was invited by the Norwegian Clean Seas Association for Operating Companies (NOFO) to participate in the 2016 Oil on Water field trial in the Norwegian North Sea. The Norwegian Coastal Administration permitted the releases of crude oil and herder and the subsequent in situ burn operations. In June 2016, three experimental offshore releases of 4.5 to 6 m^3 each (approximately 30 to 40 barrels) of Grane Blend crude oil were carried out in very low winds and seas. Two slicks were allowed to spread for 30 to 60 minutes, then herded with ThickSlick 6535 and effectively ignited with gelled gasoline igniters dropped from small boats. One control slick was allowed to spread for the same time without herding, resulting in noticeably less effective burning. In an actual incident, slicks would spread to much thinner layers over a matter of hours and not be ignitable without the use of herders or fireproof booms. Additionally, surface oil and water column samples and air samples were collected from small boats. Remote sensing resources overhead during the experiments included an Aerostat, aircraft from three nations and two UAVs. To summarize:

- The experiment successfully met its primary objective of demonstrating the use of herders in open water conditions and validating the findings of earlier field studies of herders in conjunction with ISB.
- These field experiments provided an opportunity to transfer herder and ISB technology to the Norwegian Coastal Administration and NOFO.
- The results of this exercise have important implications in developing future contingency plans to support exploration programs in both summer and winter.

Mechanical Recovery of Oil in Ice

A variety of skimmer designs have been optimized for Arctic sea conditions and several have been proven to work well. In most countries, mechanical recovery of oil is the first and preferred response. Mechanical recovery in broken ice is limited by the ability of the skimmer to encounter and remove spilled oil and to function effectively under extremely low temperatures. Another issue related to mechanical recovery is storage, transfer and disposal of the recovered oil/ice/water mixture, which is a special challenge in remote Arctic areas with limited infrastructure. The JIP commissioned internal feasibility evaluations to identify the most promising technologies or equipment designs to improve recovery of oil in ice and organized a workshop of worldwide experts in London (2012) to identify concepts that may justify further development to a 'proof of concept stage'. The concepts and the selected contractors were:

- New Vessel Design - Aker Arctic
- Remote Recovery Systems - Aker Arctic
- On Board Oil/Water/Ice Separation - LAMOUR
- Onboard Oil Incineration - SL Ross Environmental Research Ltd.

Alaska Clean Seas prepared a high level summary to consolidate the results of these four independent technical working papers. This summary document also addresses expectations of what mechanical recovery can achieve in a worst-case Arctic discharge. Key findings were:

- Mechanical recovery systems have worked effectively in the presence of ice in some situations involving small to medium spills and several commercial "Arctic rated" systems are available.

- The analysis showed that the existing systems are already operating at close to their maximum attainable recovery rate in ice. The summary identified several opportunities for incremental improvements but no feasible "game changing" mechanical recovery technology improvement or concept was identified, despite the best efforts of a large group of contributing specialists.
- This project underscored the importance of having access to dispersants and in situ burning as primary response tools in situations where mechanical recovery may have inherent limitations.

Oil Spill Trajectory Modelling in Ice

The overall goal of this research project was to conduct research investigations in ice modelling and integrate the results into established industry oil spill trajectory models. In the initial phase of this project, the Nansen Environmental and Remote Sensing Centre (NERSC) developed an improved ice model as a prerequisite for improving oil spill trajectory modeling in ice. The final report "Sea Ice Model Developments in View of Oil Spill Forecasting" (Olason et al 2016) is available on the programme's website. By delivering higher resolution, more accurate ice drift predictions, the new model offered the potential to improve our predictions of oiled ice movements.

The NERSC ice algorithms were then integrated into established commercial oil spill trajectory models (e.g., OILMAP and OSCAR) and validated against historical Arctic drift buoy tracks to demonstrate results. The outcome of this project was an increase of the oil spill trajectory models accuracy in presence of sea ice along with an estimation of the uncertainties in these trajectories at both an planning (strategic) scale and operational (tactical scale).

Project Summary

JIP research has consolidated a vast amount of existing knowledge in six key areas to provide a new baseline for future regulators, stakeholders and industry representatives concerned with assessing, approving, planning, executing and providing oversight to ensure safe Arctic drilling programs in the future. JIP scientific research has added a significant new knowledge base to the existing peer-reviewed literature on oil spill impacts on ice biota, herders and burning, dispersants, trajectory modeling, remote sensing, and trajectory modeling. Projects like the JIP reflect industry's collaborative approach to Arctic oil spill research. Advancing oil spill response is a key area where the oil and gas industry works together to achieve a common goal, believing that joining forces provides access to a much wider range of technical expertise and experience and represents a more efficient way to manage available research dollars. For more information on the JIP and to access the research reports visit www.arcticresponsetechnology.org and click on publications on the top tool bar

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