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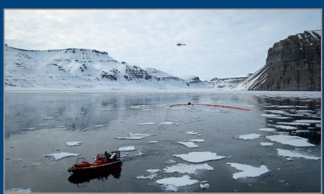
REPORT




Oil in Ice - JIP

Report no.: 25

Full scale field experiment 2009
Cruise report

Stein Erik Sørstrøm

SINTEF Materials and Chemistry
Marine Environmental Technology

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Preface

SINTEF has in cooperation with SL Ross Environmental Research Ltd and DF Dickins Associates LLC on behalf of the oil companies AGIP KCO, Chevron, ConocoPhillips, Shell, Statoil and Total initiated an extensive R&D program; *Joint industry program on oil spill contingency for Arctic and ice covered waters.* This program was a 3-year program initiated in September 2006 and finalized in December 2009.

The objectives of the program were;

- To improve our ability to protect the Arctic environment against oil spills.
- To provide improved basis for oil spill related decision-making:
- To advance the state-of-the-art in Arctic oil spill response.

The program consisted of the following projects:

- P 1: Fate and Behaviour of Oil Spills in Ice
- P 2: In Situ Burning of Oil Spills in Ice
- P 3: Mechanical Recovery of Oil Spills in Ice
- P 4: Use of Dispersants on Oil Spills in Ice
- P 5: Remote Sensing of Oil Spills in Ice
- P 6: Oil Spill Response Guide
- P 7: Program Administration
- P 8: Field Experiments, Large-Scale Field Experiments in the Barents Sea
- P 9: Oil Distribution and Bioavailability

The program has received additional financial support from the Norwegian Research Council related to technology development (ending December 2010) and financial in kind support from a number of cooperating partners that are presented below. This report presents results from one of the activities under this program.

Stein Erik Sørstrøm
Program Coordinator
(stein.e.sorstrom@sintef.no)

Funding Partners

Eni Agip KCO | ConocoPhillips | Chevron | Total | Statoil

R&D Partners

SL ROSS | DICKINS

Cooperating Partners

The Research Council of Norway | NOFO | alaska clean seas

UNIS | Oil Spill Recovery Institute Cordova, Alaska | KYSTVERKET | MMS | Coastal Response Research Center at the University of New Hampshire

SINTEF REPORT

SINTEF

SINTEF Materials and Chemistry

P.O.Box: 4760 Sluppen
Address: NO-7465 Trondheim, NORWAY
Location: Brattørkaia 17C, 4. etg.
Telephone: +47 4000 3730
Fax: +47 930 70730

Enterprise No.: NO 948 007 029 MVA

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Full scale field experiment 2009 Cruise report.

AUTHOR(S)

Stein Erik Sørstrøm

CLIENT(S)

AGIP KCO, Chevron, ConocoPhillips, Shell, Total and Statoil

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ABSTRACT

This report gives and overview of activities and main findings during the full scale field experiment carried out in the period May 9th – 25th 2009 in position N 77,30 – E 30,90 east of Hopen in the Barents Sea. Please refer to separate reports from each project for details.

KEYWORDS	ENGLISH	NORWEGIAN
GROUP 1	Oil spill contingency	Oljevern
GROUP 2	Arctic	Arktis
SELECTED BY AUTHOR	Field Experiment	Feltforsøk

CONTENTS

1 RELATION TO THE RELEASE PERMIT

The relation to the release permit issued by the Norwegian State Pollution Control Authorities is covered under each section further down in the document. The present section gives a brief summary;

- The experiment was carried out in the period May 9th to May 25th 2009 with oil on water in the period May 15th to May 21st.

- Each experiment was initiated after acquiring weather forecast for next 72 hours from the Norwegian Meteorological Institute. The weather conditions for each experiment were within predefined weather windows for each separate experiment.

- The wild life conditions in the experimental area was mapped before, observed during and mapped after each experiment. No damage to wild life was recorded during or after the experiments. See separate report.

- A comprehensive set of data was collected in relation to each separate experiment, including time, location and position for each individual experiment. All data from these recordings will be presented in separate scientific reports later this year (2009) (one from each separate project described further down).

- The system for oil spill contingency is described in the background information prior to the experiments. Actual systems for oil spill contingency were tested before initiation of each separate experiment. These systems, including a mechanical recovery system provided by the Norwegian Coastal Administration, were also operative and ready to use during the experiments.

- Remote sensing systems were in use during the experiments. They proved to be of less practical importance during the clean up operations due to weather (low visibility) conditions.

- After each experiment as well as at the end of the field operation we made a survey of wild life in the area. This is described in a separate report. The conclusion from this survey is that there were no record of conflict between the experiments and the wild life and that the remaining traces of oil represent no potential harm to the environment.

- The detailed results from these experiments will be analysed during this autumn and presented in separate reports.

- The oil from the large uncontained slick was distributed in small and fairly thin patches unsuitable for efficient mechanical recovery. Use of the new dispersant application system proved to be highly effective even after 6 days of weathering.

- The field experiment has verified previous laboratory experiments proving that the combination of a larger number of small scale laboratory and medium scale field tests (like the previous tests in Svea, Svalbard) and the full scale field experiment is necessary in developments like this.

2 OFFSHORE FIELD EXPERIMENT 2009

2.1 Introduction

Six oil companies (StatoilHydro, Agip KCO, Total, ConocoPhillips, Chevron and Shell), the Norwegian Research Council and several oil spill organizations like Alaska Clean Seas (ACS) and Oil Spill Research Institute (OSRI), USA, and The Norwegian Coastal Administration, are collaborating in the program. SL Ross Environmental Research Ltd, Canada, University of New Hampshire and DF Dickins Associates, USA is among the central R&D partners in the program.

Experimental area

The experimental area is located north east of Hopen, in the same area as FEX 2008 (May 2008). The area is sufficient far from the shore to prevent migrating birds from reaching the area during the experiment, the population density of sea mammals is low and the ice conditions is normally favourable at this time of the year.

Experience from 2008 as well as previous experiments (1992 and 1993) has shown that the marginal ice zone is a favourable area for this kind of experiment with no recorded negative effects related to previous experiments.

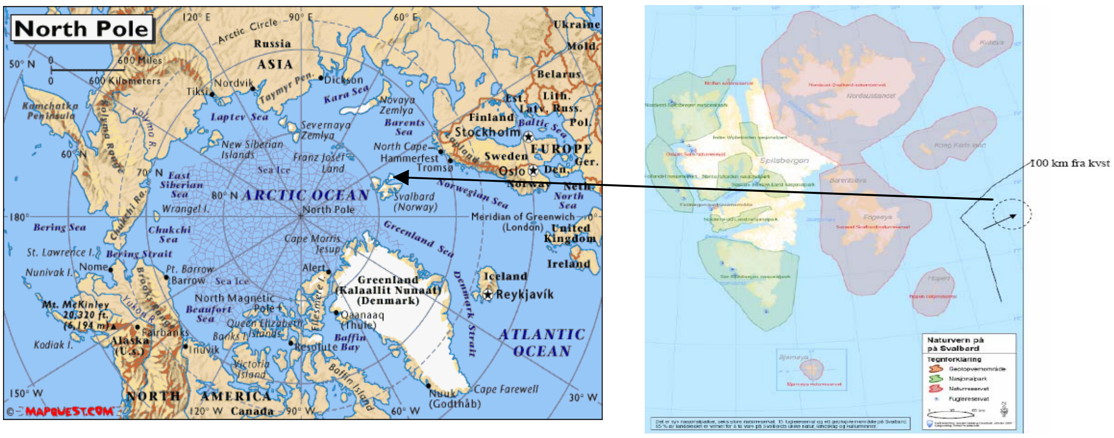
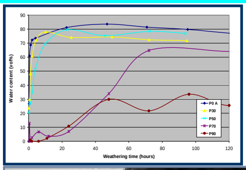
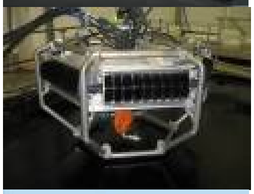
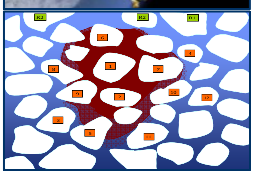
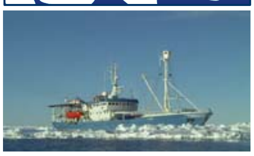


Figure 1: Experimental area. Position N 77.6, E 30.9

2.2 Project overview.

FEX 2009 is the second full scale field experiment under JIP on oil in ice and contained activities under 6 projects and 11 separate experiments;

P#[1]	Project name	Project adm. / vessel	Illustration	Scope	Conclusion
1	**Oil weathering experiments**	PJ Brandvik, RV Lance		Study of oil slick drift and weathering Defining window of opportunity	Completed as scheduled. All systems worked as prescribed. A large and valuable dataset has been collected
2-1	**Burn free floating oil**	P J Brandvik RV Lance		Burn free floating oil in ice after weathering period	Completed as scheduled. Important verification of lab tests
2-2	**Test of fire resistant booms in ice**	Ian Buist, KV Svalbard		Test of two fire resistant boom systems and in situ burning of oil in ice.	Completed as scheduled. Good results. Potential solution for ice covered areas
3	**Test of skimmers**	Ivar Singsaas KV Svalbard		Test two new skimmers developed for ice covered waters	Completed as scheduled. Valuable tests for further development of technology
4	**Test of dispersion of oil in ice.**	Per S Daling RV Lance		Dispersion of oil in ice. Test new disp. application system Vessel-facilitated dispersion process	Completed as scheduled. Good results. Promising new technology. Potential solution for ice covered areas
5	**Test of remote sensing systems**	David Dickins KV Svalbard		Test sensor systems; Handheld (IR) Airborne Satellite based	Partly completed. Missed some measurements due to external conditions. Data to be analysed
9	**Oil distribution and bioavailability**	Liv Guri Faksnes RV Lance		Map oil / WAF concentrations and record drift and spread of oil during the experiments.	Most systems worked as prescribed. A large and valuable dataset has been collected
8	**Cruise managment**	Stein E. Sørstrøm RV Lance		Overall administration	Program completed almost 100 %

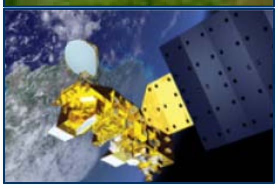
[1] Relates to project number in the overall JIP Oil in ice program

2.3 Summary of daily program

Date May -09	Main activity	Comments
09	Loading equipment. Departure from Tromsø (KV Svalbard) at 0400 pm and from Longyearbyen (RV Lance) at 0415 pm	Good sailing conditions
10	Transport to location Preparing and testing equipment Mayday signal from Russian vessel at Bjørnøya[2].	Increasing wind and waves, partly bad sailing conditions, especially during night between 10th and 11th The Russian vessel stranded on Bjørnøya in the most highly sensitive and environmentally protected area (sea birds) in Norway. No injuries to personnel. Some diesel spilled.
11	**KV Svalbard;** commanded to move to Bjørnøya to assist. Stand by at the Russian vessel until replacement by KV Harstad. **RV Lance;**Transport to location. Preparing and testing equipment. In experimental area late afternoon.	
12	**KV Svalbard;** Arrival in experimental area 0830 am on the 12th. Starts to load oil tanks from MS Nordsyssel (the observer vessel) and preparing for experiments **RV Lance;** Waiting for helicopter to locate the exact ice conditions for the experiments. Starts equipment tests without oil on the 12th	The project helicopter is onboard KV Svalbard and may therefore not be used for Lances operations. Causes approx one day delay in the program
13	**Both vessels;** Bad weather causes low visibility and consequently no window for helicopter operations, Continued equipment tests.	We try to locate relevant ice conditions partly by using satellite ice maps and also by searching with the two research vessels, but has to wait until visibility improves. The weather conditions causes additional two days delay in the program.
14	**KV Svalbard;** Bad weather causes low visibility and consequently no window for helicopter operations until late afternoon. **RV Lance;** Deployment of equipment in experimental area and preparation for release early morning on the 15th.	KV Svalbard need a larger open area than Lance for their operations
15	**KV Svalbard;** Moves to identified experimental area and starts preparations for the first skimmer test. Test completed late afternoon. Clean up completed around 1000 pm. **RV Lance;** First release of oil started 0832 am. Sampling program started.	The experiments onboard KV Svalbard is short time experiments (less than one day) while some of the experiments onboard RV Lance lasts for several days.
16	**KV Svalbard;** Moves to new area for second skimmer test. Test completed in the afternoon. **RV Lance;** Continued sampling and measurements. Prepare for dispersant test next day.	Fog creates low visibility. Large polar bear approaches area early morning, but is cared off after several signal gun flares. Test program progress as scheduled
17	**RV Lance;** Successful dispersant test (500 litre crude). Continued measurements in the large slick area	Visitors from KV Svalbard came over to Lance to watch the dispersant test.
18	**KV Svalbard;** Incident with hoses on one of the skimmers prevents further testing on the 18th **RV Lance;** Continued measurements and sampling. Test burn of oil on water on a distant part of the main slick. Ignites, but low efficiency due to small amounts of oil	Experimental site for KV Svalbards burn experiment approved. No bears, no sea birds (except very few gulls)
19	**KV Svalbard;** Problem from 18th solved in the afternoon. Starts preparing burn in boom experiment for next day. **RV Lance;** Today's releases; 2 x 2m^3 for dispersion and burning.	Burning and dispersant experiments on board Lance prepared, conducted and completed successfully
20	**RV Lance;** Final day of experiment, retrieval of equipment, final measurements and sampling, preparing to clean up **KV Svalbard;** Completed first burn in boom experiment	Efficient burn in boom experiment completed with clean up action.
21	**RV Lance;** Clean up of the large uncontained spill by use of dispersants. **KV Svalbard;** Second burn in boom experiment completed, start return to Tromsø	Efficient clean up action of the large spill, still some work left for next day. Burn in boom experiment on KV Svalbard completed successfully.
22	**RV Lance;** Clean up completed Start return to Tromsø	
23	Transport to shore, debriefing, packing of equipment	
24	**Both vessels;** FEX 2009 field program completed	Close to 100 % completion. Lot of data to be analyzed and evaluated

[2] At 05.00 o'clock in the morning of 11th May KV Svalbard received an emergency call from a Russian vessel that had grounded at the south tip of Bjørnøya. KV Svalbard being a Coast Guard vessel had to turn and go back to Bjørnøya. At 03.00 the following night we were replaced by KV Harstad. This operation caused 24 hours delay in the program.

2.4 Vessels, aircrafts, satellites

VESSEL	PICTURE	PROJECTS ON THIS VESSEL
RV Lance		P8 Cruise leader, biology and oil spill contingency, P1 Weathering, P2 Burning, part 1, P4 Dispersants, P9 Oil distribution, drift and spread
KV Svalbard		P2 Burning, part 2, P3 Mechanical , P5 Remote sensing, P8 Oil spill contingency, P9 Metocean data
MS Nordsyssel		P8 Observers
Eurocopter AS 355		P8. Various assignments for the projects (documentation, transport and safety as the most important)
Swedish Coast Guard aircraft		P5. Airborne remote sensing combined with satelite remote sensing and ground truth samples
Norwegian Coastal Administration		P5. Airborne remote sensing combined with satelite remote sensing and ground truth samples
Envisat, Radarsat-2, Radarsat-1, TerraSAR-X, CosmoSkyMed		P5. Satellite remote sensing combined with aircraft remote sensing and ground truth samples

3 PRELIMINARY RESULTS

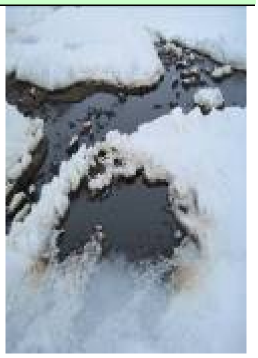
3.1 P1. Weathering of oil.

Vessel; RV Lance **Project management;** SINTEF	**Objective;** To study the weathering of oil spills in ice to verify both meso-scale laboratory studies and other field studies on Svalbard (Svea). This data is used as basis upgrading of the SINTEF oil weathering model This fieldwork was closely linked to P9, P2 and P4

Test procedure	Comments	Illustration
7 m^3 of fresh Troll B crude were released uncontained between the ice floes to study oil weathering and spreading in ice. The ice concentration in the area varied between 7/10 and 9/10. The monitoring period lasted for 6 days. Samples of oil were taken regularly to study weathering processes and to assess the potential for in-situ burning and chemically dispersing the oil	**Oil weathering** During the period May 15 until May 21, a total of 27 sampling series were performed followed by physico-chemical analysis in the laboratory at Lance A total of approx. 80 samples were collected for various analyses	
	Fate, drift and spread , the following measurements were made; GPS Position of the oil / emulsion sample spot, Oil / emulsion thickness and temperature as well as air / sea water temperature	
	Laboratory analysis: Important weathering parameters such as viscosity, water content and evaporative loss were measured close to real time in the laboratory onboard RV Lance.	
	Oil-ice-water interaction GPS trackers, under-ice current monitors, large volume water samplers, in situ oil-in-water monitoring systems and passive absorption devices were installed on the ice floes in and around the oil slick area to enable a detailed monitoring of oil-ice-water dynamics and interactions throughout the experiment.	
	Ignitability and dispersability Both dispersability and ignitability were tested with standard field tests in cooperation with P2 and P4.	

Conclusion The experiment was completed as scheduled. The onboard analyses were used to determine the dispersability as well as the ignitability of the oil during the experiments. An additional large number of samples were collected for subsequent analyses in the laboratories in Trondheim. All monitoring systems operated as required providing a large and invaluable data set for further analyses.

3.2 P9. Oil distribution, oil slick drift and oil-ice-water interactions

Vessel; RV Lance **Project management;** SINTEF	**Objective;** The objective was to collect data to provide greater insights into oil behaviour in ice with a special focus on potential environmental impacts. Collect data describing oil-ice-water interaction, oil drift/spreading to describe possible effects of oil in ice. To be used for development of numerical models describing environmental effects of oil in ice.	
Test procedure	**Comments**	**Illustration**
A series of sensors were installed in, around and under the oil slicks to monitor the uncontained slick as well as the two free floating slicks that was burned or dispersed (see next pages). In addition to this a large number of samples of oil and water were collected for further analyzes. The processes of drift, spreading and weathering of oil have been monitored by multiple sampling of water throughout the 6 days experiment	**Main oil release (P1.2 – 7 m3)** The monitoring equipment was positioned on three different ice floes or in water prior to the oil release. UVF were monitored at approximately 3 m depth **Oil release for dispersant testing (P4.1 – 2 m3)** Water samples (1L) were collected simultaneously with *in situ* UVF-monitoring and oil droplets measurements (LISST) at the same depths from the mob-boat**.**	
SPMDs are passive samplers simulating uptake of organic components in live tissue.	The SPMDs was deployed to collect time integrated data on potential bioaccumulation of oil components in the water column during the spill monitoring period.	
KISPs are automatic water samplers collecting the organic contents from a defined volume of water	The in situ large volume water sampler (KISP) was deployed to concentrate the dissolved hydrocarbons onto filters and XAD resins	
On-line UV Fluorescence is utilizing the ability of organic components to absorb energy from monochromatic light in the UV spectre and subsequent emitting a response signal that can be detected by a sensor.	On-line UV-fluorescence measurements beneath and close to the oil slick were included as a part of the hydrocarbon monitoring.	
Oil droplet size distribution measured by an on-line in situ field instrument (Sequila LISST-100X (laser diffraction)) with a droplet concentration range from 5 to 750 µL/L (size range of 2.5 to 500 µm).	Oil droplet size was monitored simultaneous with water samples and UVF measurements	
Meteorological data The meteorological station on RV "Lance" has recorded wind speed and direction, air temperature and pressure.	Meteorological data was recorded throughout the experimental period	
Currents, waves, water temperature and salinity	Oceanographic data (sea water temperature and salinity, currents, tide and wave height) were recorded by monitoring equipment on the ice and in the water.	
GPS positioning 15 GPS recorders were placed on selected ice floes in the oil slick.	For recording of ice floe drift and deformation measurements	

3.3 P2. In situ burning of a free floating oil slick in ice

Test procedure	Comments	Illustration
Vessel; RV Lance **Project management; SINTEF**	**Objective**: Verify results from experiments performed with the new laboratory burning cell and meso-scale experiments (200 L) performed at Svalbard (Svea) in 2007/08.. The data will be used to implement a capability in the SINTEF OWM predicting time window for in-situ burning of oil slicks in ice.	
A total of 2 m^3 of fresh Troll B crude was released as a free floating oil slick in 7/10 of broken ice. This oil release was performed parallel to and used as reference slick to the dispersant experiment	**Weathering and ignitability** The oil slick in ice was sampled to monitor weathering processes and ignitability. Ignitability was tested with the laboratory burning cell operated onboard RV Lance.	
	Measurements Oil sampling was performed to monitor important oil weathering properties. A possible release of oil soluble components during burning was monitored by large-volume water sampling (KISP) on continuous UVF monitoring (coordinated with P9).	
	In situ burning After 10 hours the oil slick was ignited using hand held igniters (gelled gasoline) and a successful burn that lasted for approximately 22 minutes was conducted. The experiment revealed high burn efficiency. Collected residue indicated that burn efficiency was better than 90 %	

Conclusion: The free floating oil slick was ignited after 10 hours of weathering and burned with very high effectiveness (>90%). All planned data was successfully acquired during the burning. This data will be used to enable SINTEF OWM to predict window of opportunity of in-situ burning of oil slicks in ice.

3.4 P2. In-situ burning in fire-proof booms

Vessel; KV Svalbard
Project management; SL Ross Environmental Research Ltd, Canada

Objective; To determine whether fire-resistant booms can be used to facilitate an effective burn in low concentrations of drift ice.

Test procedure

Procedure. The test procedure involved the following steps; to deploy the boom, tow it through a field of 1 to 3/10ths drift ice, monitor boom performance, collect and concentrate a 4-m^3 spill of crude oil, ignite the oil and contain it while it is burning, collect the residue, and retrieve the boom.

Ice collection. Ice was collected inside the boom and the two ends of the boom were finally secured for towing, one end held by the rescue boat and one end by the *Svalbard*.

Ignition. Several igniters[3] were deployed in the water upstream of the contained oil and ice. The igniters drifted back into the oil, and the oil was soon ignited.

Safety test. Initially a test with 200 litres was carried out to confirm that the oil would flow into the boomed area and be contained.

Main test. A volume of 4 m^3 was discharged in each test.

Residue recovery. After each test sorbent pads, rakes and shovels were used to recover as much as possible of the residue after the burn. Peat moss was finally distributed over the remaining residue and the ice/residue mixture was then released.

Two different booms were tested using this procedure

Comments

The Elastec/American Marine boom, formerly known as the 3M boom, supplied by Alaska Clean Seas[4]. The burn lasted approximately 25 minutes. Following the burn, sorbent pads were used to recover as much as possible of the residue. Based on the volume observed following the burn, the burn effectiveness was likely in excess of 90%

AFTI PyroBoom®, a more recent design produced by Applied Fabric Technologies, Inc., a subsidiary of RoClean Desmi. The ice pieces in this test were smaller and therefore packed together more densely. As well, there was more slush ice in the mix. Ignition proceeded less vigorously than in the first burn and the burn took much longer, a total of 2-½ hours. At the conclusion of the burn, burn effectiveness was estimated to be in excess of 90% based on the amount of residue remaining

Illustration

Conclusion Both booms were observed to be in good condition and could have been used in a subsequent burn. The burn experiments demonstrated that in-situ burning is a valuable response technique for oil in ice and that a successful burn can be conducted using conventional fire-resistant booms.

[3] The igniters were gelled gasoline contained in zipper-locked plastic bags.
[4] Although this boom is no longer produced commercially, there is a significant quantity of it in inventory in various locations world-wide.

3.5 P3. Mechanical recovery

Vessel; KV Svalbard Project management; SINTEF	Objective; Test new skimmers) for ice covered waters under field conditions. The development was funded from JIP Oil in ice and from DEMO 2000 (Norwegian Research Council).

Test procedure	Comments	Illustration
Two skimmers developed in cooperation with Framo, Norway and RoClean Desmi Denmark was tested. The development is funded by the Norwegian Research Council. The skimmers were tested on oil collected in the boom at about 2/10 to 5/10 ice concentrations. Up to 4 m^3 of emulsified IFO 30 was used during these tests. Each test consisted of the following activities; A boom was deployed and ice collected inside the boom. Thereafter oil was released inside the boom. The skimmer was then deployed inside the boom and the recovery rate as well as the skimmers performance in ice was recorded over a period of one to several hours. At the end of each experiment the remaining oil was cleaned out of the boom, the skimmer was flushed with water and finally retrieved for storage on deck.	**Test of the Framo skimmer**[5] The Framo skimmer was first tested without oil and then tested for approximately one hour inside the boom with oil. A new test was planned for later in the period, but cancelled due to an incident[6] that caused damage to the skimmer. **Test of the "Polar Bear" skimmer**[7] Totally 4 m^3 of emulsion was filled in the boom and totally 5 runs were performed with the Ro-Clean Desmi skimmer with varying emulsion thickness and ice coverage.	  

Conclusion. Both skimmers represent new developments based on input from the participating suppliers as well as from the expert group. Both skimmers show promising capabilities that should be further developed. The development of the Desmi RoClean skimmer is almost completed.

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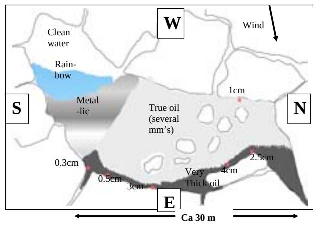
[5] Developed by Framo. Floating and with thrusters. Concept based on the HighWax system.

[6] The discharge hose and the hydraulic hoses were caught by the starboard thrusters on KV Svalbard. Further testing had to be terminated and divers were sent down to remove the hoses from the thrusters. This work went on until the afternoon of May 19th

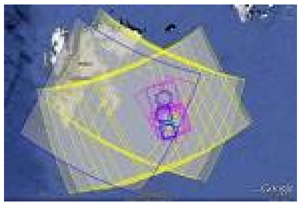
[7] The "Polar Bear" skimmer developed by Ro-Clean/Desmi is a winterized, floating skimmer with a frame designed to protect brushes from the impact of big ice floes. This skimmer can be covered with a special "roof' and be heated if needed.

3.6 P4. Dispersant tests

Vessel; RV Lance **Project management;** **SINTEF**	**Objective;** To validate the effect and the use of a new application system under real Arctic field conditions. To test dispersability of weathered crude under realistic field conditions.	
Test procedure	**Comments**	**Illustration**
The following tests were carried out; 1) Test of a new dispersant application system for Arctic and ice-covered areas. 2) Test of dispersability as a function of time and weathering. 3) Test of agitation by use of small and large vessel. The tests were carried out on three different slicks; Release of 0,5 m^3 treated after approx. 1 hour weathering, release of 2 m^3 treated after 6 hours weathering and release of 7 m^3, treated after 6 days of weathering.	**The new application system** is developed as cooperation between Jason Engineering and SINTEF and funded by JIP Oil in ice in cooperation with the Norwegian Research Council. The system is based on a manoeuvrable hydraulic spraying arm allowing a flexible application between ice floes. **Measurements and laboratory analyses** Concentration of dispersed oil in the water column *in-situ* UVF transect monitoring, as well as the oil droplets size measurements was monitored and documented throughout the various experiments.	 
Test of a new dispersant application system. After the required weathering period the slick was treated with dispersants by use of the new application system. The tests showed that the system is an improvement from previous solutions allowing for more precise application in between the ice floes.	In total the system worked as expected. The experiments revealed however possibilities for improvements of the system. This will be followed up in the next phase of the development program. I	
Test of dispersability as a function of time and weathering. The weathering period was 1 h, 6 h and 6 days respectively for the three tests.	Weathering properties as well as oil dispersability was studied in the onboard laboratory. The oil was still dispersible after 6 days.	
Test of agitation by use of small and large vessel. Due to high ice concentrations, the energy input in the oil-ice system was very low. To enhance the dispersion process, we used Lance as well as the smaller water jet mob boat to enhance the dispersion process.	The agitation by vessels proved to be highly efficient giving an immediate dispersion of the treated oil. After treatment of the various slicks, it was estimated that less than 5-10 % oil remained on the surface as a thin oil film on water and on the edges of the ice floes.	
Treatment of the large uncontained slick After 6 days weathering and extensive monitoring of the large uncontained slick, it was decided to terminate the experiment by treating the remaining surface oil/emulsion with dispersant.	To enhance the dispersion process, we mainly used the water-jet of the mob-boat to create turbulence. Especially in the narrow leads between the ice floes, this methodology proved to be highly efficient.	

Conclusion 1) Use of the new dispersant spray-arm in combination with use of the thrusters on Lance as well as the water jet system on the small boat proved to be an effective method to enhance the dispersion process. 2) Less than 5 – 10 % of the released oil was left on the surface after completed treatment. 3) The FEX 2009-experiments represents the first time where dispersants has been applied in full scale to an uncontained oil slick in high ice concentration. FEX 2009 confirmed previous laboratory tests at SINTEF as well as earlier observations of a series of smaller-scale experiments with vessel-facilitated dispersion.

3.7 P5; Remote Sensing

Vessel; KV Svalbard **Project management;** **DF Dickins Associates**	**Objective;** Test airborne and satellite born remote sensing systems for their capability to detect oil in ice covered waters	
Test procedure	**Comments**	**Illustration**
Airborne surveillance. The large spill took place between 0830 and 0900 (Local) on the 15th of May. The Swedish aircraft made several passes over the test site during a 40 minute period from 1250 to 1330 – approximately 4 hours after the release.	During the time when the aircraft was on site, the oil was contained in approx. 9/10 ice cover and prevented from spreading more than a few tens of meters by the very close pack ice and slush filled leads. Analysis of the full resolution airborne data will be conducted to assess the potential to map larger spills.	 *The Swedish surveillance aircraft and crew at the airport in Longyearbyen*
Satellite Acquisition KSAT[8] acquired over 35 images from different satellites beginning May 9 and running until both vessels left the area on May 22. Rapid southerly ice drift rates created by strong W to NW winds from May 16 to 19 created a major challenge in keeping the main target oil spill within the narrow swath width (25 to 45 km) of the highest-resolution satellites. SAR platforms used in the project were Envisat, Radarsat 1 and Radarsat 2 in addition to the high-resolution COSMO-SkyMed radar. In addition to the SAR data, a very clear Quickbird visible image with KV Svalbard in the frame was obtained on May 16.	At time of writing, the study team is still interpreting the satellite data and comparing individual images with all possible targets represented by different activities on the surface. Due to the ice conditions it is not possible to say whether or not the oil can be detected.	 *Figure indicating the area of coverage by the various satellites.*
Handheld IR camera. A chronological comparison of visual and IR images of the main uncontained spill was assembled by personnel onboard RV *Lance* with good results during daytime as shown in the example below to the right. Efforts to use the same model of IR camera to view oil being discharged into the fire-resistant boom off the stern of the *Svalbard* showed no measurable temperature difference between the oil and water.	 *Large uncontained P1.2 spill after four days at sea. Taken at day-time from the Lance crows nest. During daytime, the IR sensor (left) was able to distinguish between oil (white), ice-free water (light grey and snow and clean ice floes: dark grey. Photo: Per Daling*	

[8] KSAT = Kongsberg Satellite Services, Tromsø

3.8 P8. HMS, wild life, oil spill recovery

Vessel; RV Lance and helicopter **Project management; SINTEF**	**Objective;**. To avoid conflicts with and environmental damage to sea birds and sea mammals. To ensure safe work and safe working environment for personnel.	
Test procedure	**Comments**	**Illustration**
HES, confidentiality and safe job analysis	All participants signed HMS and confidentiality declaration at the start of the cruise. First officer on board gave instructions / training on onboard HES requirements. Each briefing meeting was initiated with a Safe Job Analysis. We experienced one incident causing damage to some of the equipment but without any injuries to personnel.	
Wild life	During the experimental period we observed 9 polar bears from the vessel and 5 from helicopter as well as various limited numbers of sea birds. No sea mammals or sea birds came in contact with the oil. See separate report on wild life conditions during the experiment.	
Oil spill clean up	We conducted a thorough clean up after each test, partly by use of mechanical recovery and absorbents after the skimmer tests, by use of mechanical recovery of residue and use of absorbents after the in situ burning tests and by use of dispersants as part of the dispersant tests as well as for clean up of the large uncontained spill. Only traces of oil (sheen on the water) were left on the surface when the clean up was concluded	

4 CONCLUSIONS

The Joint Industry Program on oil spill contingency for Arctic and ice covered waters in general as well as the Full scale field experiment 2009 in particular has provided a lot of valuable information about oil spills in ice and state-of-the-art response techniques.

The two full-scale field tests (FEX 2008 and FEX 2009) have verified the results of the small-scale experiments and have given the participants a unique opportunity to test the actual response techniques in the real-life Arctic environment. The invaluable knowledge gained as a result of these activities will help to better respond to Arctic oil spills and will influence future R&D in this area.