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REPORT

Oil in Ice - JIP

Report no.: 18

Full scale field experiment 2008 Summary of results

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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.

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Funding Partners

Agip KCO ConocoPhillips Chevron Shell 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

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Summary of results.

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CLIENT(S)

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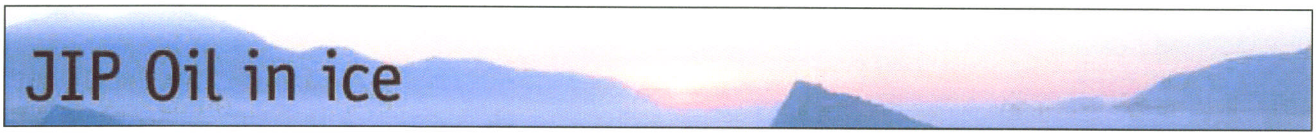
ABSTRACT



This report gives an overview of activities and main findings during the full scale field experiment carried out in the period May 18th - 28th 2008 in position N77.30 – E 30.90, East of Hopen in the Barents Sea. Please refer to the 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

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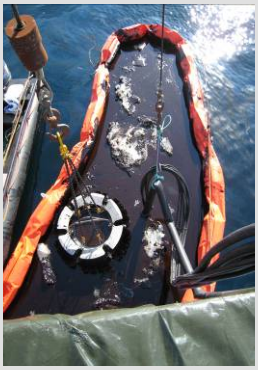



1 INTRODUCTION

The 2008 field experiment under the *JIP Oil in ice – program* was carried out in the period of May 18th-30th 2008 in the vicinity of position 77,6 – 30,9 (East of Hopen in the Barents Sea) in an area covered by a slightly drifting (north to south) and opening ice field.

The full scale field experiment was completed with almost 100 % accomplishment in relation to plans and two days ahead of schedule.

The following program was included;

- 10 separate skimmer tests with three different skimmers
- two experiments with towing of two types of fire proof booms in ice,
- two open water and ice burn experiments
- one remote sensing experiment (with SAR-satellite)

The released oil was either collected by skimmers or removed by burning. Each experiment was concluded with a clean up operation and only a few liters of residue was left on the surface after clean up. This residue was treated with absorbing pads and bark. None of the experiments has resulted in pollution of the surroundings.

The experiments has verified findings from laboratory tests and supplied additional important knowledge for the development of oil spill contingency for ice covered areas.

1.1 Overview of field program

Date	Activity
18-05-2008	Arrival at Lance. Cargo loading
19-05-2008	Departure from port Briefing of participants, Safety instructions, HES and Confidentiality declaration Continue transport to location
20-05-2008	Briefing of today's activities "Dry-test" of skimmers and boom. Position 77,48 - 29,34. Helicopter survey to find an open space in the ice. Slightly opening ice. Approximately 90-100 % coverage with open "ponds in between
21-05-2008	Briefing of today's activities, Helicopter survey, Test of Desmi Helix skimmer with 1 m^3 of emulsion Clean up with skimmer, pads and absorbing booms.
22-05-2008	Briefing. Decided to run test-burn as planned Slightly modified test program. Burn test successfully completed. Start preparing Lamor skimmer – dry test. Test of functionality to see if every thing is OK. Plan for tomorrow and next days
23-05-2008	Aerial survey. Start preparing skimmer test. Lamor skimmer, Sea Mop and Desmi Helix skimmer (once more)
24-05-2008	Briefing. Second herd and burn test. 1711 Oil release Takes less than 2 minutes, Wind speed 3,5 m/s - Application of herder-Ignition – burn lasts approx 8 minutes. Preliminary estimated burn efficiency 90 %
25-05-2008	Transport back to Longyearbyen for unloading of skimmers, loading of booms.
26-05-2008	Transport and prepare for shipment of equipment
27-05-2008	Booms loaded. Transport to Billefjord. Experimental site for boom towing experiment AFTI boom test. 3M boom test.
28-05-2008	Transport back to Longyearbyen. Unloading. Departure from Longyearbyen

2 PROJECT DESCRIPTION

The experiment lasted for 15 days (from port to port). 4 days were spent during transport between Longyearbyen and the experimental site.

We carried out the following tests;

- Test of skimmer capacity and capability in approximately 30-50 % ice coverage. The following skimmers were tested; Lamor LRB skimmer, Desmi Helix skimmer and Desmi Rope Mop skimmer.
- Test of herding of a free floating oil slick in ice and subsequent burning of the oil.
- Test of fire-proof booms in ice. Towing experiment to test durability and operational characteristics.

2.1 Mechanical recovery – skimmer tests.

The skimmer tests were carried out on May 21st and May 23rd. Each test was carried out by deploying a containment boom of 25 meter length forming a small basin with a diameter of approximately 8 m. Inside the boom we collected enough ice to cover approximately 30 % of the surface area inside the boom. 1.5 m^3 of oil emulsion (50 % water content) was released inside the boom and the three skimmers was tested a number of times to record their ability to collect oil (recovery rate) and the ability to "process" the ice (ability to deflect ice to prevent ice from clogging the recovery pump of the skimmer).

- On the 21st we carried out a series of tests with the DESMI Helix skimmer.
- On the 23rd we carried out a series of tests with the Lamor skimmer followed up with test of the Sea Mop and finally the Desmi Helix skimmer once more.

		
Testing of the Helix 1000 skimmer during the experimental field trial in May 2008	*Testing of the LRB 150 skimmer during the experimental field trial in May 2008*	*Testing of the RopeMop 4090 skimmer during the experimental field trial in May 2008*

2.2 Herding and burning experiments

The herding and burning experiments were carried out on May 22nd (test burn) and May 24th (main burn) in the same area as the skimmer tests.

2.3 Boom towing experiments

The boom towing experiments were carried out in Billefjord close to the abandoned Russian mining town Pyramiden. No oil was involved in these tests.

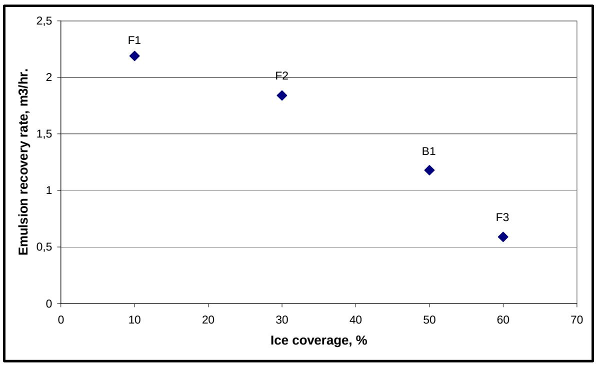
3 SUMMARY OF RESULTS

3.1 Skimmer tests

See report from Singsaas et al 2008 for further details.

3.1.1 Testing of the Helix 1000 skimmer

Measured emulsion recovery rate for the Helix 1000 skimmer as a function of ice coverage, using broken ice. F = field testing; B = basin testing.



The figure indicates a trend that the recovery rate will decrease with increasing ice coverage, using an ice scenario with broken ice.

In the slush ice scenario the Helix skimmer worked quite well with a higher measured recovery rate than in the broken ice scenario

Basin testing of the Helix 1000 skimmer

			Recovered				Recovery rate calculated		
Test no.	**Ice conditions**	**Recovery time, min**	**Total amount, l**	**Free water, l**	**Free water, %**	**Water in emulsion, %**	**Total m3/hr.**	**Emulsion m3/hr.**	**Oil m3/hr.**
B1	Broken, 50 %	52	1167	142	12	50	1,35	1,18	0,59
B2	Slush, 100 %	15	1314	0	0	50	5,26	5,26	2,63

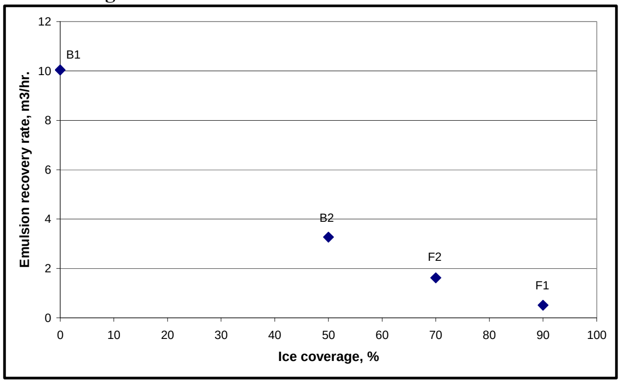
Field testing of the Helix 1000 skimmer

			Recovered				Recovery rate calculated		
Test no.	**Ice conditions**	**Recovery time, min**	**Total amount, l**	**Free water, l**	**Free water, %**	**Water in emulsion, %**	**Total m3/hr.**	**Emulsion m3/hr.**	**Oil m3/hr.**
F1	Broken, 10 %	12	590	152	26	47	2,95	2,19	1,16
F2	Broken, 30 %	16	527	36	7	53	1,98	1,84	0,87
F3	Broken, 60 %	13,5	132	0	0	53	0,59	0,59	0,28

Flow of emulsion to the skimmer	The Helix skimmer recovers the oil that reaches the brush array quite effectively. Cohesive slicks can be drawn into the brushes provided a moderate drum speed (5-10 rpm). The Helix skimmer has no built in buoyancy and is dependant on a crane both for vertical and horizontal positioning. The skimmer works in between the broken ice pieces and must be repositioned when the oil layer around the skimmer reaches a lower critical thickness.
Ice processing - the skimmer's ability to deflect the ice for easier access to the oil.	The Helix skimmer can process relatively small ice floes to a certain degree at low ice coverage. With increasing ice coverage the ice processing capability, as defined here, decreases. This is due to the configuration of the skimmer which then has to be moved around in the ice field.
Separation of oil, water and ice Uptake of free water is dependant of the vertical position of the skimmer in the water as well as brush speed.	The uptake of free water varied between 0 and 26 % in the testing performed. During the field experiment the submergence depth of the brushes in the water was estimated to approximately 2 - 4 cm. During the field testing the uptake of free water seemed to decrease with increasing ice coverage. Because of the construction of the skimmer it can not take up ice pieces, but slush ice can enter the sump. The skimmer is equipped with a powerful screw auger pump which is able to pump slush ice back to the receiving tank.
Icing / freezing of equipment.	The Helix skimmer is not constructed for cold conditions. As long as the skimmer is in the water the pump will not freeze. However under cold conditions the upper parts of the brushes are exposed to wind and low temperatures. The skimmer needs to be modified before it is used under very cold conditions in the Arctic.
Conclusions and recommendations	This is a small skimmer and large recovery rates should not be expected, even in low ice concentrations. However, the principle of this skimmer, with rotating brush drums, seems to work quite well in certain ice conditions. Based on this testing the following recommendations have been worked out: • The discharge and hydraulic hoses should be connected on top of the skimmer. • Operation of the skimmer would benefit from a built-in buoyancy of the skimmer. • The Helix skimmer is relatively small and unprotected and can be damaged between ice floes. • The skimmer should be "winterized" if used under conditions with low temperatures.

3.1.2 Testing of the LRB 150 skimmer

Measured emulsion recovery rate for the LRB 150 skimmer as a function of ice coverage, using broken ice. F = field testing; B = basin testing.



Recovery rate for the LRB skimmer decreases with increasing ice coverage, using an ice scenario with broken ice.

In the slush ice scenario the LRB skimmer worked quite well with a recovery rate similar to the testing without ice

Results from field testing of the LRB 150 skimmer.

			Recovered				Recovery rate calculated		
Test no.	Ice conditions	Recovery time, min	Total amount, l	Free water, l	Free water, %	Water in emulsion, %	Total m3/hr.	Emulsion m3/hr.	Oil m3/hr.
F1	Broken, 90 %	11	93	0	0	44	0,51	0,51	0,29
F2	Broken, 70 %	18,5	501	0	0	55	1,62	1,62	0,73

Results from basin testing of the LRB 150 skimmer.

			Recovered				Recovery rate calculated		
Test no.	Ice conditions	Recovery time, min	Total amount, l	Free water, l	Free water, %	Water in emulsion, %	Total m3/hr.	Emulsion m3/hr.	Oil m3/hr.
B1	No ice	14	2342	0	0	45	10,04	10,04	5,52
B2	Broken, 50 %	19	1090	55	5	50	3,44	3,27	1,63
B3	Slush, 100 %	14	2163	108	5	50	9,27	8,81	4,41

Flow of emulsion to the skimmer

Normally this skimmer is operated from an excavator type of crane where the angle can be adjusted from the vessel deck. In correct angle the brush drum creates a flow of oil under the skimmer from behind and towards the brushes. In this way the skimmer can set up a steady flow of emulsion to the skimmer without actually have to be moved around in the oil.

Ice processing

Because the skimmer sets up a flow towards the brush drum also ice pieces will be drawn under the skimmer by this flow being set up. When reaching the brushes the ice pieces will be pushed into the water and the oil will be released and recovered by the brushes. The skimmer seems to deflect ice pieces up to approximately 1 m diameter in an efficient manner.

Separation of oil, water and ice

Due to the direction of rotation for the LRB skimmer, which is opposite to the Helix skimmer, it is anticipated that the uptake of free water is less sensitive to both the submergence depth and the rotational speed compared to the Helix.

Icing / freezing of equipment.

As for the helix skimmer, the LRB skimmer was not subjected to extreme weather conditions during this testing. Since the basin testing in 2007 the manufacturer have installed heating possibilities of the scraper board prior to the field experiment.

Conclusions and recommendations

It can be concluded that the LRB skimmer represents state-of-the-art technology regarding recovery of oil spills in ice field. By use of the original excavator crane and an experienced operator this skimmer is expected to have the potential to effectively recover oil in ice up to ice concentrations of 60 – 70 %.

Due to the flow created under the skimmer it showed good ice processing capabilities with low uptake of free water. A short test with cleaning of ice surfaces (on to of ice floes) showed that the skimmer was also capable of cleaning ice.

3.1.3 Testing of the SeaMop 4090 skimmer

The SeaMop skimmer was subjected to only a limited testing during the field trial. It has not been tested in the laboratory. Testing of a Rope mop skimmer was requested by members of the project Reference group as it is currently included in the oil spill contingency for Arctic areas.

Results from (limited) field testing of the RopeMop 4090 skimmer

			Recovered				Recovery rate calculated		
Test no.	Ice conditions	Recovery time, min	Total amount, l	Free water, l	Free water, %	Water in emulsion, %	Total m3/hr.	Emulsion m3/hr.	Oil m3/hr.
F1	Broken, 60 %	15	NA	NA	NA	NA	Priming of rope mops with oil		
F2	Broken, 60 %	15	546	160	29	53	2,18	1,54	0,73

Flow of emulsion to the skimmer

We observed a certain flow of emulsion to the rope mops, but this was somewhat restricted due to high ice coverage. In this experiment approximately 2 m, out of the totally 15 long rope mops, was in contact with the oil, water and ice.

Ice processing

Due to the relatively high ice coverage (approximately 60 %) ice processing was somewhat restricted.

Separation of oil, water and ice

A free water uptake of approximately 29 % was measured in this test.
Due to the good weather conditions during this test, ice formation was not observed.

Icing / freezing of equipment.

As for the other skimmers tested, the RopeMop skimmer was not subjected to extreme weather conditions during this testing. Therefore no icing or freezing of the equipment was observed.

Conclusions and recommendations

Rope mop skimmers are oleophilic skimmers dependant on the oil's ability to adhere to the mops. The very limited test performed during the field experiment demonstrated the rope mops ability to coat the emulsion used during this testing and lift it to the wringer in the skimmer unit.
Often when using a rope mop skimmer from a vessel side, the height from the sea surface and up to the skimmer unit can be several meters (typically +/- 6 meter). Most rope mop skimmers are exposed to freezing under extreme conditions when hanging in the air.

3.2 Herding and burning experiments.

See report from Ian Buist, SL Ross for further details.

3.2.1 Description

Description	Comments
Objective and Goal	The objective of this study was to continue research on the use of chemical herding agents to thicken oil spills in broken ice to allow them to be effectively ignited and burned in situ. More specifically, the goal of the work described here was to conduct two meso-scale field burn tests with crude oil slicks of approximately 0.1 and 0.7 m^3 in open drift ice off Svalbard in May 2008.
Experimental set up	The first, smaller test was carried out by releasing the crude oil into a monolayer of herder that had previously been applied to the water. The second, larger test involved releasing the oil onto the water, allowing it to spread, then applying the herder on the water around the edge of the slick from small boats.
Documentation and sampling	Once the slick had finished spreading (based on aerial observations of the slick from the helicopter) or contracting oblique aerial digital photographs were taken at an altitude of about 100 m to record the size of the slick. Digital video of the ignition and burn was taken from the helicopter in order to document burn times and areas. Once the slicks had extinguished, aerial photographs were taken to document the residue area. Samples were taken from one of the boats to estimate the reside thickness.
Ignition	Ignition was attempted initially by hand from a small boat positioned at the upwind edge of the free-floating herded slicks. Baggies containing about 120 mL (4 oz.) of gelled gasoline were placed in the slick near the edge and ignited with a propane-fuelled soldering torch. Eventually, this technique was used to ignite slicks herded against ice edges.
Residue recovery	Personnel in small boats recovered as much of the residue as possible with the pre-weighed sorbent materials in order to obtain an estimate of the oil removal efficiency. The recovered burn residue was placed in plastic garbage bags and returned to the research vessel for water decanting, drying, re-weighing and disposal.
Burn Calculations	Burn efficiency and burn rate were calculated for each experiment using equations (1) and (2), respectively. Burn efficiency is the ratio of the mass of oil burned to the initial oil mass. Oil burn rate is a measure of the decrease in the oil thickness over the period of the burn, from the time when 50% of the slick area is aflame (ignition half-time) to the time when the flame area has decreased to 50% of the slick area (extinction half-time). If 100% flame coverage was not achieved, the rate is corrected by employing the maximum percent flame coverage observed. $\text{Burn Efficiency (mass \%)} = \frac{(\text{(Initial Oil Volume x Oil Density) - Residue Mass) x 100\%}}{\text{Initial Oil Mass}}$ $\text{Oil Burn Rate (mm/min)} = \frac{\text{(\% Burn Efficiency) x (Initial Oil Volume)}}{\text{(Slick Area) x (Max. \% Flame Cover) x (Extinction Half-Time - Ignition Half-Time)}}$ The residue was assumed to be water free.

3.2.2 Test burn, May 22nd 2008

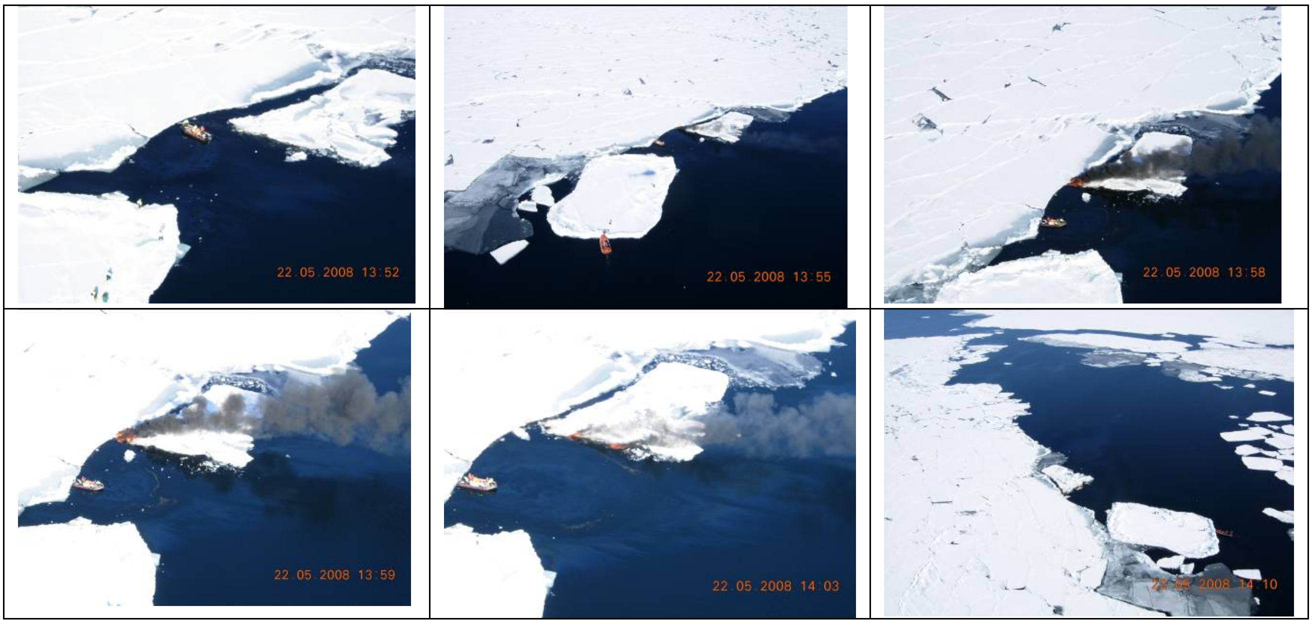
DESCRIPTION	COMMENTS
Test burn, May 22nd.	The first field test, on 22/05/08, involved 102 L of fresh Heidrun crude released onto the water from the edge of a floe at approximately 1330 CEST. Approximately one liter of USN herder had already been sprayed onto the water beside the floe, because there were concerns about the marginal wind speeds rapidly breaking up the small slick (winds were 5 to 5.5 m/s measured with a handheld anemometer on the floe). The oil did not spread significantly when released into the herder monolayer; however, before it could be ignited, the oil unexpectedly moved 90° to the left of the wind direction into a small pocket between two large floes and collected against an ice edge.
Ignition	Three successful burns of the oil in the pocket and against the edge of the adjacent floe were initiated over a 13-minute period.
Recovery of residue	As much as possible of the residue and unburned oil was recovered using the small boats with pre-weighed sorbent pads and short sections of sorbent boom. The initial estimate of burn efficiency is 80%.

Burn data collected on May 22.

Burn #	Ignition (min:sec)	Time to Flame Coverage (min:sec)			Extinction (min:sec)	Comments
		50%	100%	50%		
1	0:00	3:05	3:25	6:16	8:02	Burn travels along back edge of floe at end
2	7:40	8:10	8:27	-	10:43	Video off for 50% extinction
3	9:55	-	10:49	12:29	13:04	Video off for 50% ignition
Reside Collection						
	Weight of Oily Sorbent After 24 hours Decant (kg)		Weight of Clean Sorbent (kg)		Residue Weight (kg)	Burn Efficiency (mass %)
All 3 Burns Combined	33.4		15.3		18.1	*80*

Estimated slick areas from aerial photo analysis. Oil release time; 13:30

Photo Time	Slick Area (m^2)	Average Slick Thickness (mm)
13:32:14	30.89	3.3
13:32:54	30.05	3.4
13:39:02	57.44	1.8
13:39:10	59.78	1.7
13:40:18	38.41	2.7



3.2.3 Main burn, May 24th 2008

DESCRIPTION	COMMENTS
Main burn on May 24th.	The second test on May 24 involved releasing an accurately measured 0.63 m^3 of the fresh Heidrun crude oil from four drums tipped over on the side of a large floe among very open drift ice. The oil was allowed to spread on the water for approximately 15 minutes. Herders was applied along the sides of the slick The crude was allowed to spread until the thick portion had reached an equilibrium area (as judged from the helicopter) and the thick portion was still a relatively contiguous slick. Once the slick had finished spreading (based on aerial observations of the slick from the helicopter) oblique aerial digital photographs were taken at an altitude of about 100 m to record the size of the herded slick and samples of the slick were taken to determine slick thickness.
Ignition and burning	The first igniter was placed on the upwind edge of the herded slick and the burn finally extinguished 9 minutes later after a large, intense burn traveling the length of the herded slick.
Recovery of residue	As much as possible of the residue and unburned oil was recovered using pre-weighed sorbent pads, short sections of sorbent boom and a full section of sorbent boom. Observations from the helicopter indicates that some residue was left on the surface after clean up.
Burn efficiency	The initial estimate of burn efficiency (pending receipt of the measured density of the Heidrun crude at 0°C) is 90%. A very rough estimate of the amount burned based on burn times, burn areas estimates and a nominal 3.5 mm/min burn rate is near 100%.

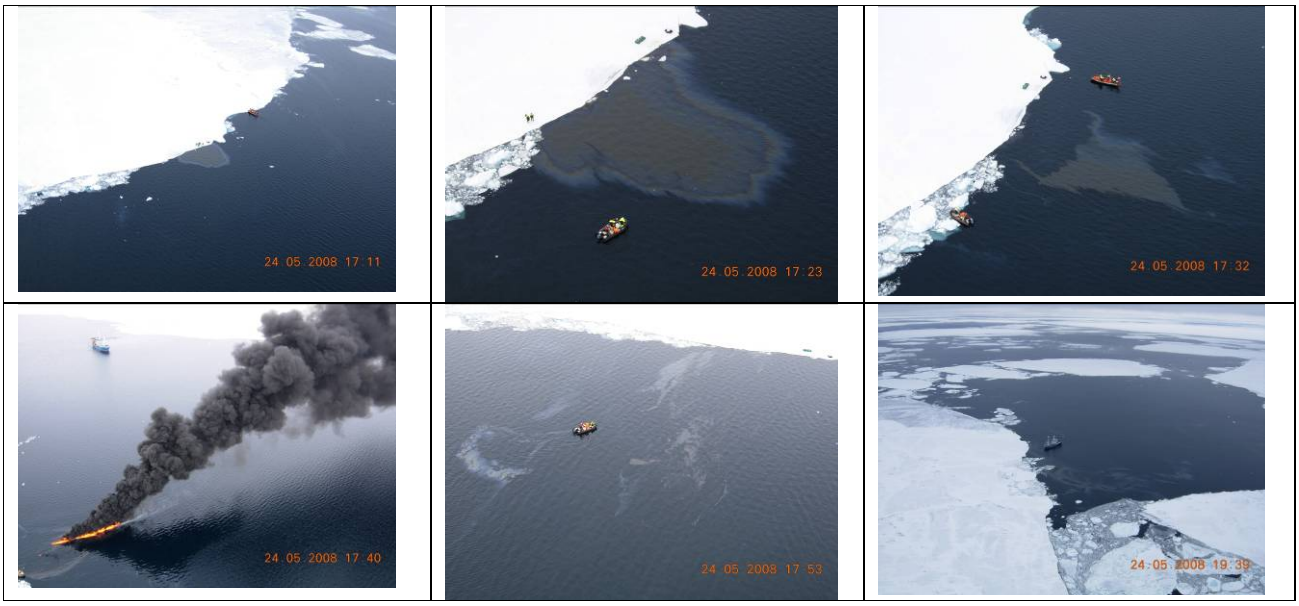
Burn data collected on May 24.

Burn #	Ignition (min:sec)	Time to Flame Coverage (min:sec)			Extinction (min:sec)	Comments
		50%	100%	50%		
Upwind	**0:00 (17:36:40)**	**1:50**	**2:07**	**3:48**	**4:02**	**Upwind area ≈ ½ of total; upwind extinguished as downwind ignited**
Downwind	**-**	**4:07**	**5:23**	**7:05**	**8:56**	**Formed long, narrow fire**
Reside Collection						
	Weight of Oily Sorbent After 24 hours Decant (kg)		**Weight of Clean Sorbent (kg)**		**Residue Weight (kg)**	**Burn Efficiency (mass %)**
Both Burns Combined	**79.0**		**46.2**		**32.8**	***94*[1]**

[1] Review of aerial photos and video indicates that not all the unburnt oil and burn residue was collected therefore this burn efficiency estimate is high.

Estimated slick areas from aerial photo analysis. Oil release time; 17:10

Photo Time	Slick Area (m^2)	Average Slick Thickness (mm)
17:24:50	1658	0.4
17:34:48	403	1.6
17:37:41	153	4.1



3.3 Summary of 2008 field test of fire-resistant boom in ice

See report from Steve Potter, SL Ross for further details.

The goals of this year's work were to confirm the operability of two selected fire-resistant booms and to practice procedures for a more extensive test in 2009 involving oil and an actual burn.

Two fire-resistant booms were used: the Elastec/American Marine Boom (formerly known as the 3M Boom) supplied by Alaska Clean Seas, and the AFTI PyroBoom supplied by Applied Fabrics International Inc. Aspects of operability that were tested included: deployment from an ice-capable vessel-of-opportunity, operability in low concentrations of ice without debilitating damage, measurement of tow loads when ice was present in the boomed area, and the ability to maneuver around large ice floes.

The tests involved deploying the boom, and establish a U-configuration using the Lance and a jet-boat as the tow vessels. The boom was first towed in open water to establish baseline tow loads. The boom was then used to collect ice floes, as would be the case in oil-collection mode in a field of trace ice concentrations. The boom was maneuvered to avoid large ice floes.

Observations were made of the time required to deploy and the difficulties in deployment. Aerial video and visual observations were made of the ice accumulation within the boom while under tow. Load cells on each of the towlines were used to measure tow loads with and without ice in the boom. Tow speed was recorded as a direct readout from the bridge on the Lance; this will be compared with data from GPS that was positioned on each of the towing boats to determine boat position and speed.

In general terms, both booms were successfully used to create a collection area for oil in the presence of trace ice, and were able to maintain typical containment performance at tow speeds up to 1.5 knots, i.e., in excess of the tow speed suitable fort effective containment. Neither boom suffered debilitating damage as a result of the exercise and, as such, should both be suitable for the planned tests in 2009.






4 OTHER IMPORTANT ASPECTS.

4.1 Relation to the release permit

- The experiments were carried out in the period 18.-28. May 2008 in the vicinity of position 77. 6 ^{0} N, 31 ^{0} E
- Before and during each separate experiment the weather forecast was acquired.
- One scientist had the responsibility of recording the wildlife (sea birds, sea mammals) prior to each experiment. No conflicts between the experiment and the wildlife were recorded during the experiments (see separate report on this).
- Time, place and criteria for each experiment were recorded. Details on this subject will be included in the scientific reports from the experiment.
- Probable drift and spread of oil was evaluated before each experiment. Positions and other related data will be included in the scientific reports.
- Oil spill equipment used during the experiments was tested without oil prior to experiment and ready to use during the experiments.
- An oil spill recovery backup system was ready to use during each separate experiment.
- By the end of each experiment we carried out a survey in the experiment area to record possible environmental conflicts. No incidents were recorded during or after the experiments.
- The project involved four main experiments with oil or emulsion.
  - The two skimmer experiments involved release of 1-1.5 m^3 of emulsion (0.5-0.75 m^3 of oil). This emulsion was recovered and only trace amounts (blue sheen) of oil were left on the surface after experiment.
  - The burn experiments involved a total of 0.8 m^3 of oil. Approximately 0.7 m^3 was removed by burning and the residue was recovered by adsorbents. Only trace amounts (blue sheen) were left on the surface.
- For further results from each separate experiment se last chapter of this report as well as scientific reports to be finalized later this year.

4.2 Helicopter operations.

DATE	LIFT	LAND	TIME	ACUMULATED	MISSION
20.05	14:05	14:23	0:15	0:15	Checking ice conditions
21.05	8:00	8:30	0:30	0:45	Reconnoitering birds and mammals
	9:00	9:05	0:05	0:50	Checking ice conditions
22.05	8:10	8:46	0:35	1:25	Reconnoitering birds and mammals
	12:29	12:39	0:10	1:35	Checking ice conditions
	13:30	14:17	0:45	2:20	Recording oil in ice
	18:30	19:25	0:55	3:15	Checking ice conditions vs. satellite pass
23.05	8:07	8:27	0:20	3:35	Reconnoitering birds and mammals
	16:05	17:00	0:55	4:30	Checking ice conditions vs. route for Lance
24.05	13:14	13:36	0:20	4:50	Checking ice conditions
	14:10	14:20	0:05	4:55	Checking ice conditions
	15:56	16:17	0:20	5:15	Reconnoitering birds and mammals
	16:58	18:03	1:05	6:20	Recording burning of oil
	18:43	19:50	1:05	7:25	Checking ice conditions vs. route for Lance
26.05	21:00	21:44	0:40	8:05	Checking ice conditions Tempelfj./Billefj.
27.05	13:05	13:30	0:25	8:30	Recording boom operation
	14:05	14:30	0:25	8:55	Recording boom operation
	16:50	17:08	0:15	9:10	Recording boom operation

The helicopter operations were characterized by a number of short flights lasting from 15 minutes to 1 hour and 5 minutes. During the 8 days period from May 20th trough May 27th we had a total of 18 flights with an average duration of 30.6 minutes.

4.3 Oil recovery and clean up after test.

Each test was concluded with oil recovery and adjacent clean up with sorbents, pads and bark.

The skimmer tests were carried out with 1.5 m^3 oil in each test. The oil was released inside a containment boom and recovered with the skimmers that were subject to testing. The flow rate and recovery rate of the skimmers was recorded giving a good control over the amount of recovered oil. After each separate test the final clean up was carried out manually with absorbing pads and booms and finally bark if needed.

The two herding and burning tests were carried out with 102 liter and 630 liters of crude oil respectively. The crude oil was released on the water surface in an area with approximately 10-30 % ice coverage. After release of oil a small volume (approximately 1 liter pr test) of chemical herders was applied on the outskirts of the slick causing a distinct contraction of the oil slick. After a short herding process the oil was ignited causing removal of approximately 80% (80 liters) of the small test slick and approximately 94 % (592 liter) of the large slick. The remaining oil on water was mainly blue sheen and residue. The residue was collected with absorbing booms and pads. Some minor traces of oil on the ice edge were treated with bark.

The boom towing experiments was carried out to test the durability of fire proof booms in ice. These tests were carried out without release of oil.

During the tests no conflicts between sea birds and sea mammals was recorded (see separate report on birds and mammals studies during the experiment).

4.4 Final conclusion.

The experiment has given highly valuable information for further development of oil spill technology for Arctic and ice covered waters. The program was completed as scheduled except for the remote sensing part. No accidents occurred during the experiment and no environmental conflicts with birds and mammals were recorded.