2006 Svalbard Experimental Spill to Study Spill Detection and Oil Behaviour in Ice

Summary Field Report

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Submitted by:

DF Dickins Associates Ltd.
info@dfdickins.com

SINTEF
per.brandvik@sintef.no

The University Centre at Svalbard (UNIS)
liv-guri.faksness@unis.no

Boise State University
johnb@cgiss.boisestate.edu

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BACKGROUND

The test plan distributed in February 2006 summarized previous work leading up to the experimental spill on Svalbard and outlined a field program incorporating three main engineering and scientific research components: remote sensing; oil in ice, fate and behavior; and countermeasures (in-situ burn) evaluation.

This summary field report provides a diary of field activities beginning with the successful skirt insertion in February and ending with demobilization of the scientific team on March 30.

FIELD TEAM

The project team included following organizations and key individuals with primary responsibilities identified.

David Dickins, DF Dickins Associates Ltd.	Co-coordinator for remote-sensing project components
Per Johan Brandvik, SINTEF/UNIS	Co-coordinator for oil fate and behavior research and countermeasures evaluation
<u>Oil Fate and Behavior Technical Team:</u>	
Kristin Rist Sørheim, Scientist, SINTEF	Oil sampling and analysis
Bror Johansen, Senior field engineer, SINTEF	Logistics, dive leader
Frode Leirvik, Field engineer, SINTEF	Logistics/sampling, diving
Liv-Guri Faksness, PhD student, UNIS/UiB	Ice/oil sampling and analysis
Roger Daniloff, MSc student, UNIS/NTNU	In-situ burning of oil in melt pool
<u>Boise State Remote Sensing Technical Team</u>:	
John Bradford, Faculty	GPR and acoustic evaluations
Lee Liberty, Faculty	
Troy Brosten, PhD Student	

SPONSORS ATTENDING

Organization	On-site Representative
MMS	Sharon Buffington
ADEC	Dianne Munson
STATOIL ASA	Gunhild Neverdal
Shell Technology Norway	Gina Ytterborg
Sakhalin Energy Investment Company	James Robinson
Alaska Clean Seas	Lee Majors

OVERALL PROGRAM SCOPE AND OBJECTIVES

The 2004 tank tests showed that GPR systems could detect and map oil pools as thin as one inch (2 to 3 cm) under controlled conditions under model sea ice up to 16 inches (40 cm) thick. This field experiment creates a larger-scale spill under thicker natural sea ice to further evaluate potential remote sensing systems as practical operational tools and to study oil in ice fate and behaviour.

Objectives - Oil and Ice Detection

- Test ground penetrating radar in the 200 to 1,000 Hz frequency range with crude oil spilled under natural sea ice up to 1 metre in thickness in both surface and airborne modes.
- Test currently available acoustic technology as proof of concept.
- Investigate the levels of hydrocarbon gases within the ice above trapped oil by collecting and analyzing water and ice samples. The ultimate goal here is to determine whether these levels are sufficient to support effective surface or airborne detection with more portable and sensitive new-generation ethane sensors in future experimental spills such as those being planned for Canada and Norway beginning in 2007.

Objectives- Oil Fate and Behavior in Ice and Clean-up Effectiveness

- Document the vertical migration rate of oil as a function of air and ice temperatures and ice crystal structure, salinity and brine volume.
- Map and document oil distribution and spreading under the ice (thickness, area coverage).
- Document the rate and extent of oil encapsulation following the spill (any new ice growth beneath the oil).
- Document migration of water-soluble components through the ice, and evaporation and possible emulsification on surface melt pools.
- Evaluate the effectiveness of in-situ burning when the oil surfaces.

OVERVIEW OF FIELD ACTIVITIES

Two spill containment skirts were installed as 11.2 m diameter circles (100 m^2) through 45 cm ice, February 20-22. The two test areas were installed in line with the prevailing wind direction approximately 30 m apart. The skirt depth of 150 cm allows for ample material hanging beneath the ice. Pockets are fabricated in the skirt to contain 2x4" wooden flotation rods on top and small iron bar to weight the bottom (Note: the radar signal does not penetrate into the seawater; consequently, the presence of metal below the ice is not an issue).

The full field team arrived in Svea on March 24 and 25 after completing safety training (lectures and firing range) at UNIS in Longyearbyen during several days of bad weather. Conditions on site improved markedly from the 25th on, and moderate to low winds and clear skies favored the remaining test period. Prior to the spill, the radar team surveyed the ice in both skirts and selected the optimum area in terms of the radar response (both sites appeared to have similar variability in ice thickness). In compliance with the terms of the spill permit, underwater camera surveys were conducted around the skirt at six points to confirm that the skirt was hanging evenly beneath the ice with no kinks or openings for the oil to flow out.

A series of pre-spill ice cores, air and water samples were taken at various locations outside the test skirts and packed for shipment to the UNIS laboratory in Longyearbyen (ice structure and dissolved h.c. analysis) and the ETI labs in Houston (trapped h.c. gas analysis). Ice salinity measurements were made with melted samples on site.

A 3-D radar survey of the ice area incorporating the chosen containment skirt was conducted on March 26 one day prior to the spill. Snow depths were measured at 80 points within the spill skirt and showed a range of 4 to 30 cm in hard undulating drifts.

Ice thickness at the time of the spill ranged from 60 to 70 cm compared to an average of 1 to 1.1 m more typically encountered at the end of March (reflecting the late freeze-up experienced in 2006).

The spill took place as scheduled on March 27. Oil was injected under the ice through a neutrally buoyant pipe inserted through an augur hole drilled at an angle just outside the skirt. A total of 3,400 litres of fresh Stratfjord crude was pumped from drums over a period of 2 hours. Air temperature at the time was -15°C, and the oil was close to ambient. No difficulties were encountered in the pumping. The progress of the oil injection was monitored and recorded by an underwater camera focused on the end of the injection pipe approximately 1 metre inside the skirt. The same camera was periodically moved to different inspection holes around the skirt perimeter to monitor the progress of the advancing oil boundary as the test area approached 90%+ coverage.

Following the spill, the radar team repeated the full 3-D survey with antennas at different frequencies over the oiled site, including clean ice comparisons outside of the skirt. On

March 28, the radar was mounted under an AS350 helicopter and flown over the spill site and surrounding area at three different altitudes (approx 3 to 12 m) and a range of forward speeds up to 20 knots.

Diving operations took place on three different occasions between March 27 and 29. A novel under-ice thickness sensor was tested and used successfully to measure the oil thickness (three points simultaneously) at different locations reached from two separate dive holes. While the average film thickness was in the 3 to 4 cm range, as expected, the natural variability in the ice thickness (±5 cm) led to deeper pockets of oil in localized areas within the skirt. Observations and underwater photographs were taken to show the appearance of the oil layer and the progress of new ice growth at the edge of the oiled area within 48 hours of the spill.

A final set of water, air and ice cores were taken on March 29 prior to demobilizing. These samples included three cores through the top 20 cm of the ice inside the test area. One of these cores confirmed the presence of oil in the brine channels to within 17 cm of the surface. In addition, one core immediately outside the skirt showed a band of very fine oil droplets (0.2 to 0.5 mm) in the skeletal layer (bottom 2.5 cm). These droplets represent an insignificant fraction of the total oil volume that was dispersed through the shearing action as the oil left the discharge pipe.

The project was carried out on schedule in accord with the proposed daily test activities outlined in the original Test Plan (February 2006). Figure 1 shows the spill location on Spitsbergen. Figure 2 is an Aqua satellite image acquired March 27, 2006 as the oil was being discharged (250 m resolution).

Figure 1 Location of spill site denoted by arrow.

Figure 2 NASA MODIS image from the Aqua satellite over Spitsergen, March 27 2006. Spill site marked by small circle.

OVERVIEW OF KEY FINDINGS

- Surface-based radar at 500 MHz showed distinct phase shift over areas with oil present, in contrast to the signatures over clean ice
- Radar accurately mapped ice and snow thickness from the surface
- Airborne radar unable to detect ice water interface or "see" the oil (airborne potential still exists with higher power systems)
- Airborne radar gave detailed profile of the snow/ice interface and demonstrated a high potential to map oil under snow on the ice surface
- Acoustics showed mixed results related to ice in homogeneity
- Samples were taken for trapped h.c. gases in the ice related to future application of ethane sensors (currently being analyzed)
- Evidence of new ice growth at the perimeter of the spill as well as new crystals showing at the base of the oil layer within 48 hours of the spill.

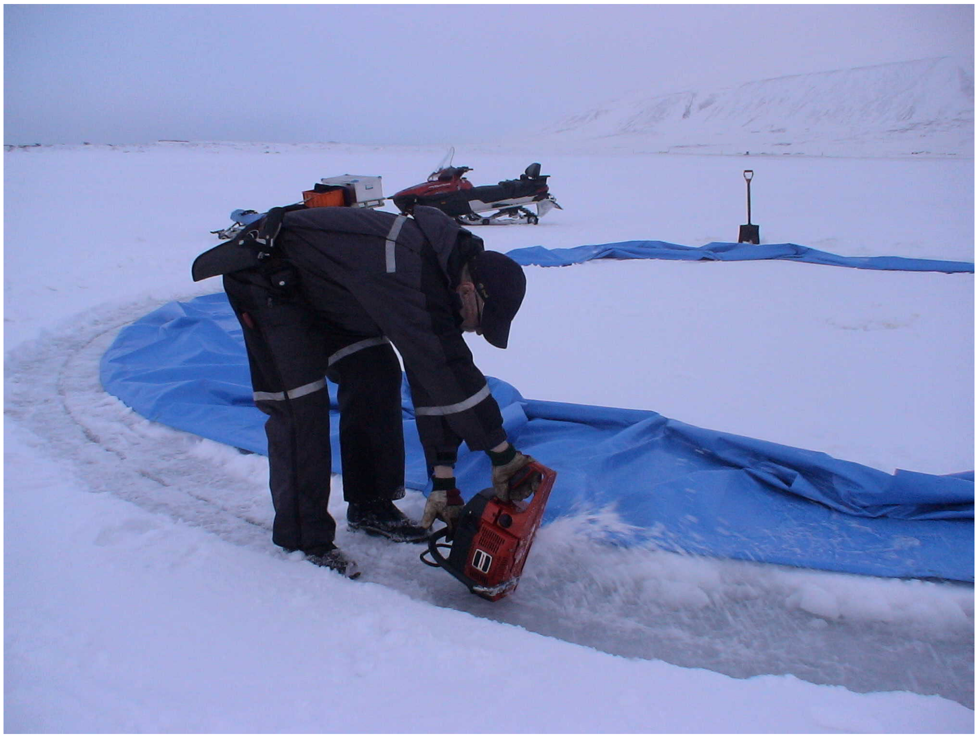
ONGOING PLANS

SINTEF personnel, stationed in Svea after mid-April, will monitor the progress of oil migration prior to the spring in-situ burn evaluation. Once the majority of the oil has surfaced and is still in a relatively fresh state, the oil will be ignited and a full documentation conducted of the burn effectiveness and residue.

There is a possibility of over flying the site in May prior to the burn with a specialized remote sensing aircraft carrying a laser fluorosensor along with other IR, UV and visible sensors (negotiations in progress).

In addition, consideration is being given to conducting a brief one day repeat survey with the radar in late April to examine the configuration where the oil is trapped within the ice by new ice growth beneath the oil (new crystals were observed at the edge and on the bottom of the oil layer within 48 hours of the spill).

PHOTO ALBUM



Cutting in the oil skirts February 2006

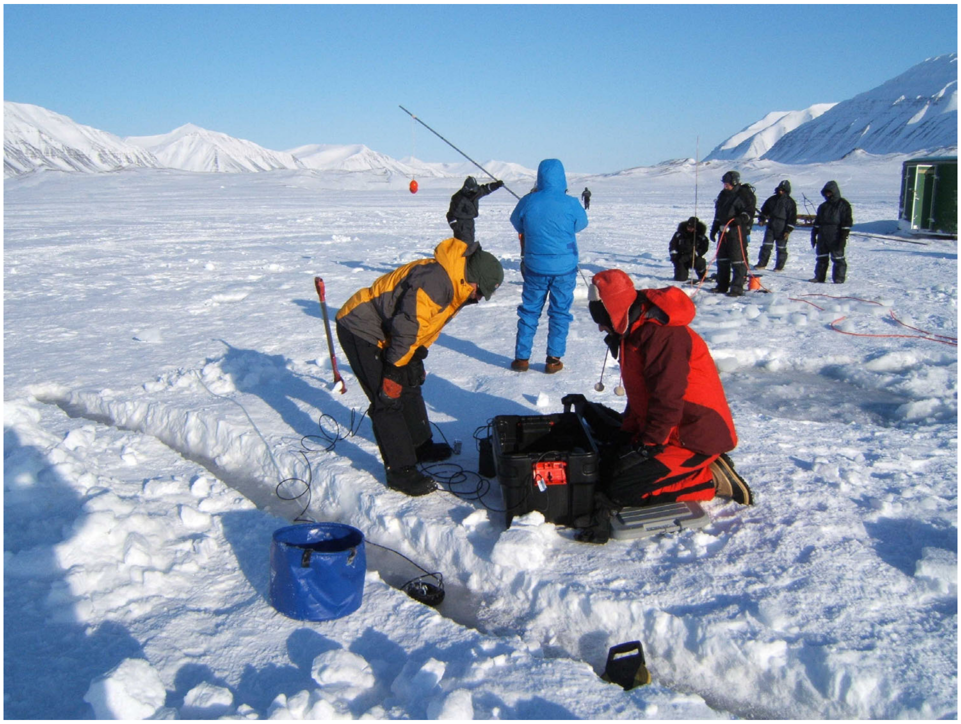
Completed skirt installation

Pumping oil from drums through flexible pipe inserted 1 m inside skirt through a sloped hole drilled 2 m outside

Taking an ice core

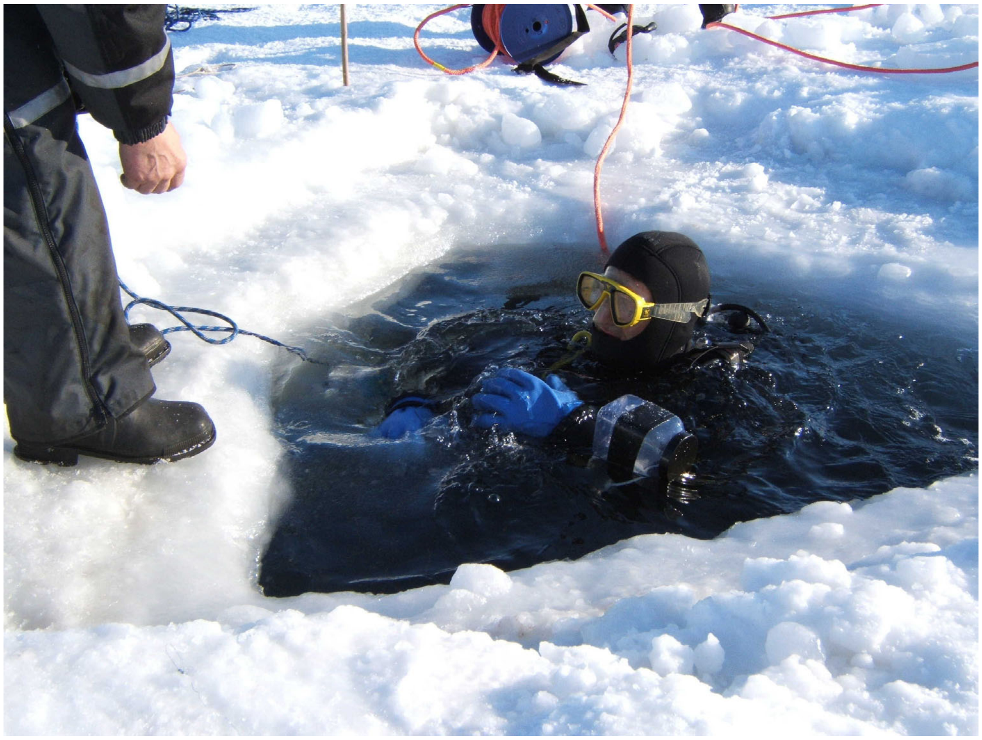
Radar surface traverse along a marked survey line

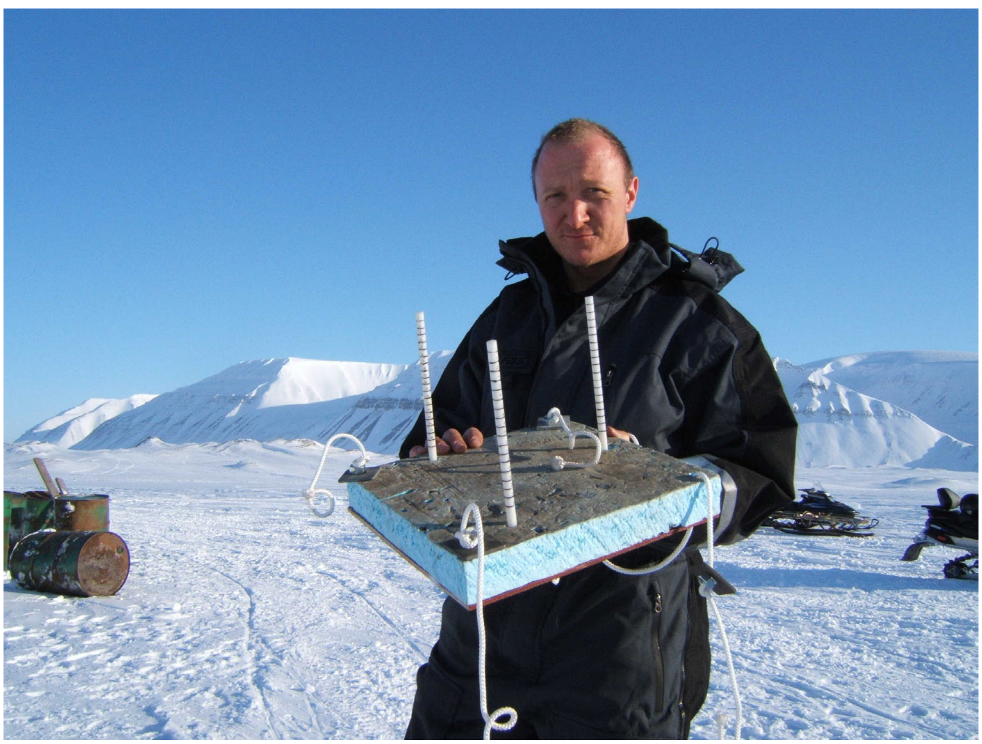
Radar being flown over the oiled area

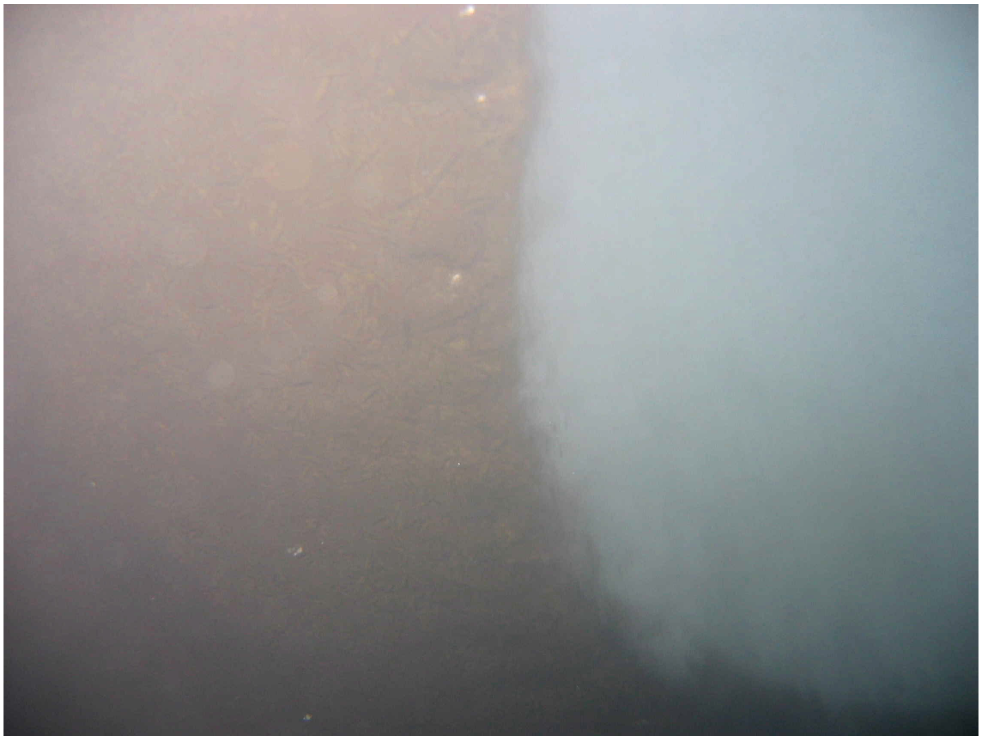


Testing the acoustics system by moving the transducer along a trench straddling clean and oiled ice. Water was used to wet the ice to improve coupling.

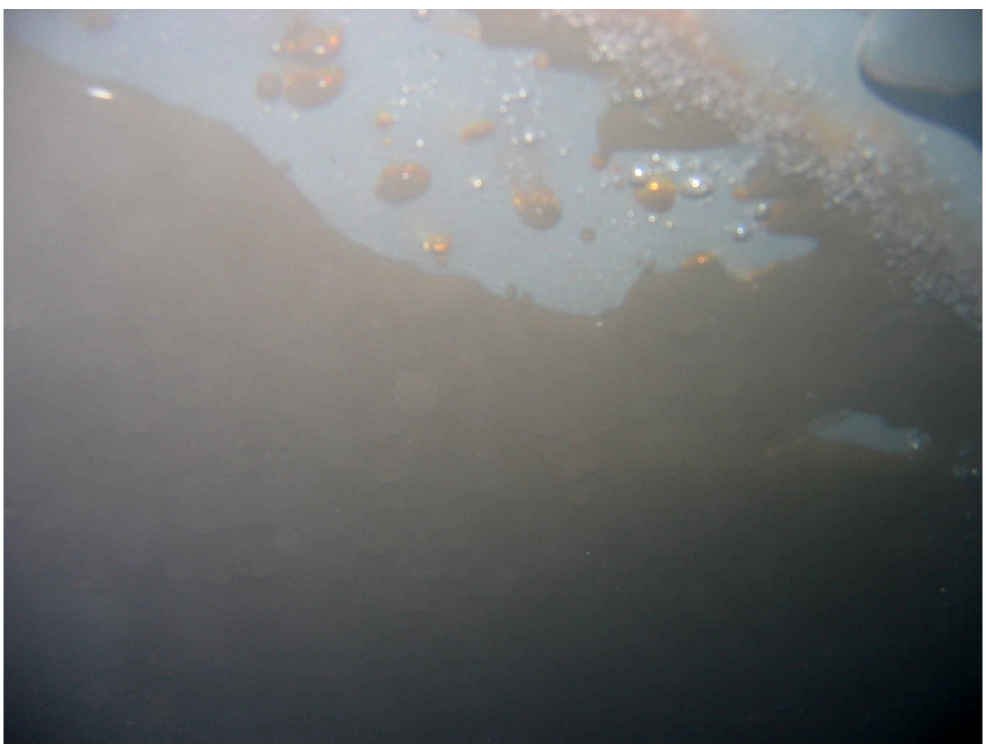
Extracting an ice block while cutting a dive hole just outside the skirt

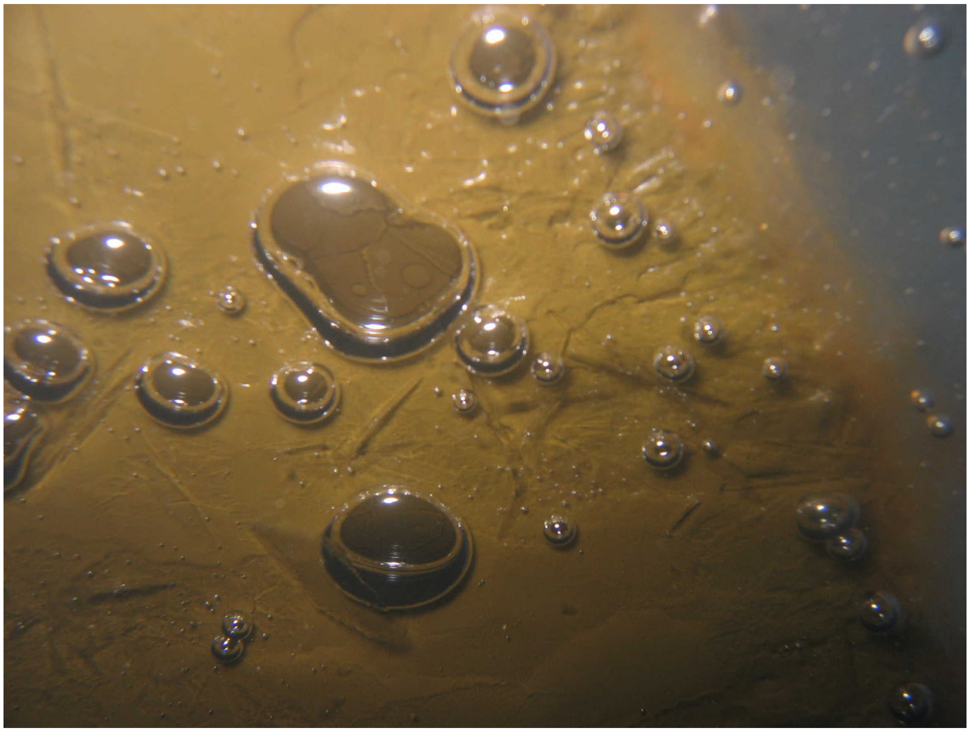

Diving operations


SINTEF prototype under-ice oil thickness sampler



Diver photographs of oil spreading under ice





View of oil layer under the ice showing evidence of large, new ice crystals floating within the oil