OIL SPILLS IN SEA ICE
Past, Present and Future

Concluding Statement and a Research Agenda
"THE FERMO STATEMENT"

An advanced study workshop on "Oil Spills in Sea Ice – Past, Present and Future", was held at the Istituto Geografico Polare "Silvio Zavatti", Fermo, Italy, from 20-23 September 2011. 33 delegates from 12 countries considered the question

How can we design an effective, integrated system for dealing with every aspect of a potential accident in ice covered waters which involves the release of oil?

The workshop was opened with a keynote speech by Walter Munk. During three days, papers were presented on every aspect of oil interaction with sea ice, with a primary focus on the implications of a blowout occurring during exploratory drilling, although oil spills from Arctic shipping accidents were also considered. The final day was devoted entirely to a panel discussion on our present state of knowledge of oil spill physics and on defining the areas on which new research is most vital. Funding support was provided by the US Office of Naval Research Global, and the Municipality of Fermo.

The following points reflect the areas which the delegates considered particularly important and urgent in improving our state of knowledge of oil spills in sea ice. This list of 12 themes represents a critical oil-in-ice research agenda that can be used by public and private organizations to determine research priorities in this field.

1. **How best to stop a blowout.** Given the serious environmental impact of an oil blowout on the vulnerable Arctic, the highest priority must be given to methods which shorten the period during which release takes place. Until recently primary reliance has been placed on bringing in a second drilling rig and drilling a relief well even though it could take 60-90 days before successfully controlling and killing the well. Far more useful, in our view, would be a pre-engineered capping system with the ability to install a replacement blowout preventer. If prebuilt and available for rapid deployment such a system could much more rapidly bring the well under control. This is distinct from a containment system, also proposed by various oil companies, which collects oil from a blowout in a sort of hood, with the oil then needing to be removed from site and disposed of at intervals.
2. **How to model oil spread.** It is assumed that oil from a blowout rises in an oil-gas plume, impinges on the lower surface of an ice cover, is encapsulated by the growth of new ice underneath it, and drifts through the Arctic until released in spring by ascent through brine drainage channels to the ice surface. Every stage in this process needs to be modelled and studied more carefully, with special concern about the spring emergence process in the case of multiyear ice where the nature of the brine drainage channels is not well known. Models that have been developed for this process need to be intercompared, in the same way as the Arctic Sea Ice Model Intercomparison Project, to determine which models have validity and predictive power. The

small-scale behaviour of oil being encapsulated in ice of different ages and types needs to be measured and modelled by laboratory experiments.

3. **Tracking oil spills.** We do not know enough about the detection of oil spills from space. This applies both to oil spills from marine accidents – ships which sink in ice – and to oiled ice from blowouts where the oil reaches the ice surface in spring and summer after being encapsulated in the ice and drifting with it during the winter. More work, including field trials, needs to be done with electro-optical sensors, including hyperspectral systems, ground penetrating and synthetic aperture radar (SAR). Technologically advanced satellite, aircraft, and unmanned airborne, seaborne and undersea systems should be exploited and integrated into an effective observing network.
4. **Problems with *in situ* burning.** Although *in situ* burning has been recommended and tested as a technique for disposal of Arctic oil, we do not fully understand the contribution to pollution by the smoke plumes or by the burn residue, especially its potential toxicity. The knowledge base needs to be assimilated into a rigorous net environmental benefit analysis (NEBA).
5. **The role of dispersants** needs to be studied in far greater detail, especially their potential chronic long-term effects. They have been employed in massive quantities in existing spills e.g. Gulf of Mexico, and are currently favoured as a treatment for an Arctic blowout, yet we need to know far more about their effectiveness and toxicity in the Arctic environment.
6. **The physics of large-scale oil entrapment** by features in the ice cover needs to be determined, so as to show whether simple geometric models of oil spread in rough ice are valid. In particular, the porosity of pressure ridges to oil needs to be determined experimentally.
7. **The biological consequences of oil spills** in Arctic waters need to be studied in greater detail. These can range from effects on large mammals (e.g. contamination of seal breathing holes) to small-scale effects (e.g. role of Arctic ocean bacteria in oil consumption, or the effects of sunken oil spill residues on the benthic community). Another key threat is to migratory birds who typically gather in marginal ice zone areas and leads in summer, which is exactly where and when previously entrapped oil is released into the environment. This is an area where the traditional knowledge of indigenous people can be of immense value in the detection of effects and changes, especially in habitats and species movements.
8. **The rapidity of environmental change** is affecting our oil-ice modelling in ways that we cannot fully encompass. Changes in water temperature, ice thickness and ice roughness affect both the mechanics of oil containment by ice and the physics and chemistry of oil interaction with the water column. We need to monitor key Arctic environmental change parameters systematically even though it can be a difficult or lengthy process to derive the rate of change of extreme parameters, such as the depth of the deepest pressure ridge in a given region or the areal extent of deformed ice.
9. **Data sharing and management.** It has often been the case that similar studies of oil-ice interaction have been carried out by industry and academia, with results not being fully shared. Future research on oil in ice should be carried out within the context of data interaction and sharing, such that full benefit can be gained by science from the efforts on both sides. A comprehensive data management system for oil-in-ice results would ensure maximum advantage from the limited opportunities that are available for controlled oil releases.

10. **A rapid scientific response** is needed when any opportunity arises to study oil-ice interaction in the field, e.g. a marine accident in ice. Any such event should be studied not just from the immediate viewpoint of clearing up the threatened pollution, but also with the larger aim of understanding the nature of the interactions that are taking place.
11. **Delivery of the oil to the ice underside** is a critical function of time of year and state of the sea or ice surface. Studies to date have focused on delivery to the bottom of an established first-year ice sheet, yet a blowout at the end of summer could begin with the oil interacting with a newly freezing water surface or with a variety of young ice types such as frazil, pancake or nilas. How early-winter oil is incorporated into a subsequently growing ice sheet needs to be studied.
12. **The natural background** should be studied in any spill situation. Natural oil seeps occur in many areas that are vulnerable to oil spills, e.g. along the Beaufort Sea coastline and in Baffin Bay, and have an impact which needs to be distinguished from the residual effects of a cleaned-up spill.

It is undeniable that prevention is always better than cure. Prevention of Arctic oil spills can be improved with better information and monitoring. Risks of a surface or subsurface oil spill from shipping or exploration drilling can be decreased if the operations are better designed for the geologic, marine traffic and environmental conditions that may be encountered in a changing Arctic. This includes designing for a wide range of changing ice conditions, storm events, and increased marine traffic. Better understanding of location specific risks requires high resolution temporal and spatial monitoring data and more research into low frequency extreme events.

The workshop was an important opportunity to bring together the expertise of those who are currently active in Arctic oilspill protection efforts and the experience of those who have worked steadily in this field since Arctic offshore development began in the early 1970s. During the 40-year lifetime of Arctic oil-ice research the number of field experiments involving controlled releases of oil has been very small; every study has had to bear the weight of contributing significant new results and providing a testbed for a wide range of new techniques. Given that the Arctic is now being subjected to both an acceleration in the rate of exploratory drilling and a large increase in maritime traffic, it is inevitable that oil-ice incidents will occur, and we need a much more systematic and sustained research effort than has been possible hitherto, in order to be in the best position to cope with an oil release incident and its environmental consequences.

The Oil Spills in Sea Ice workshop was not sponsored by either the oil industry or by NGOs. The concerns and recommendations expressed by its participants are based purely on our recognition of a clear scientific need.

The Chairman and organizer of the meeting was Dott. Maria Pia Casarini, Director of the Istituto Geografico Polare "Silvio Zavatti" (email zip.fermo@gmail.com) and the organising committee comprised Prof. Peter Wadhams (University of Cambridge, p.wadhams@damtp.cam.ac.uk), David Dickins (DF Dickins Associates LLC, La Jolla, dfdickins@sbcglobal.net), Dr Mark Myers (University of Alaska Fairbanks, mdmyers@alaska.edu) and Dr Lawson Brigham (University of Alaska Fairbanks, lwb48@aol.com). The proceedings will be published by the Institute and refereed papers will appear in a special volume of the journal "Cold Regions Science and Technology" edited by Peter Wadhams.