Detection of oil in sea ice
(remote)

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Oil spills and sea ice

Need a holistic approach to understand oil and sea ice: :

- Oil-ice interaction, weathering and modelling,
- Oil detection and monitoring,
- Oil Spill Response Techniques.

Different types of oil spill accidents

- Shipping accident:
  - On known shipping lanes,
  - generally (but not exclusively) under summer conditions.
- Pipeline breach:
  - Close to shore
  - Anytime of year, but breach due to ice scouring will have a high probability during the sea ice season
- Blow-out:
  - known location,
  - generally drilling under summer conditions
  - Oil will be mixed with gas.

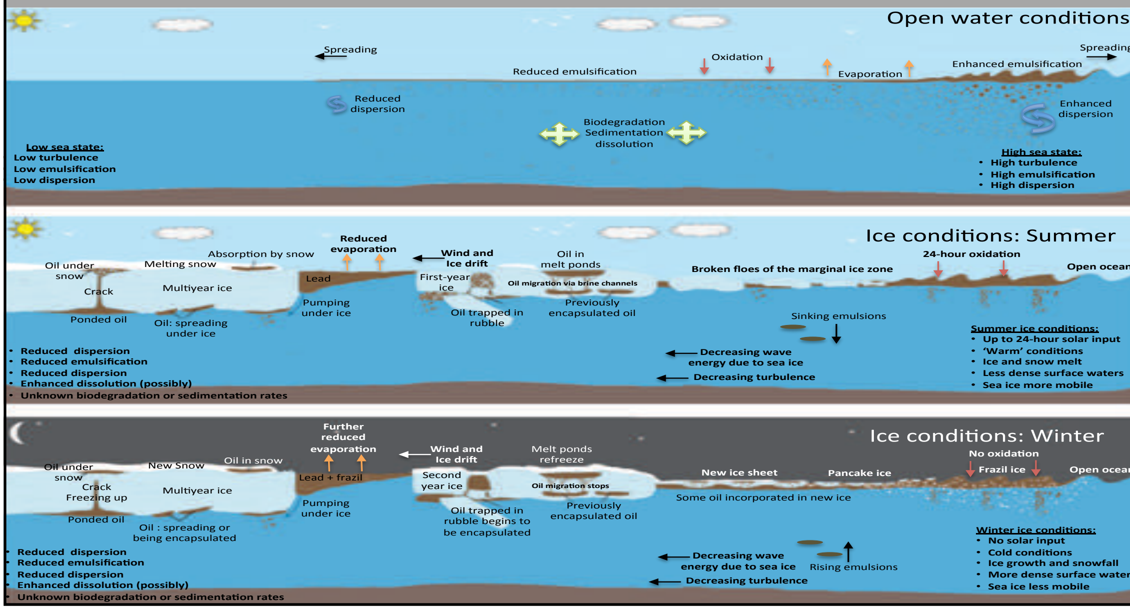
Different oil and ice types

- Tremendous amount of oil types
  - Crude oils of different origin vary widely in their physical and chemical properties.
  - Refined products tend to have well-defined properties irrespective of the crude oil from which it was derived.
- Tremendous amount ice types.
  - New ice: frazil, nilas and pancake ice
  - Level first year ice
  - reasonably level multiyear ice
  - Ridged ice and rubble fields
  - Marginal ice zone: mixture of ice types, concentration change quickly
  - Drifting and fast ice

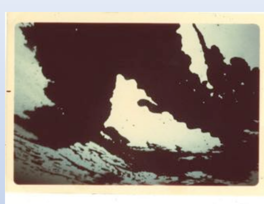
Need to understand how different oil types will interact with these ice types

Then can better understand how best to detect oil spilled in, on and under these ice types

Conditions: open water, summer and winter

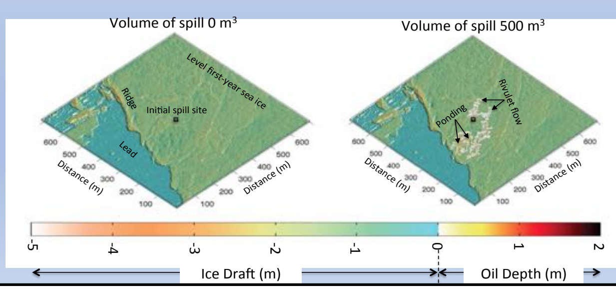


Oil spreading: depends on ice topography



Oil forms both ponds as a well as small rivulets that move from one depression to the next. NORCOR oil under ice recovery tests Beaufort Sea, May 1975

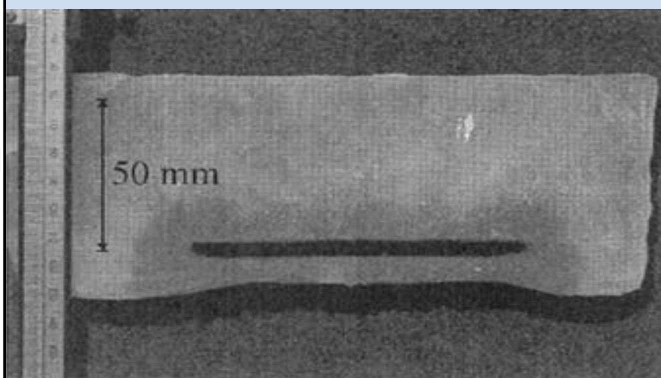
- Equilibrium thickness: about a centimetre
- Movement very much dependent on under ice topography
- Thickness of oil varies, but gathers thickest in depressions.
- Drifting pack: Thickness of oil dependent on the rise rate and drift velocity of the ice
- Very little information on what happens in an oil gas mix i.e. blow out situation



Under ice oil trajectory model run on real ice topography.
Left: Ice conditions before oil spill applied.
Right: Results after 500 m^3 of oil spilled at the black square region in the centre of the image.
Oil spread shows both rivulet flow and ponding. Overall modal oil thickness under this level first year ice was just a few centimetres. (Wilkinson 2012).

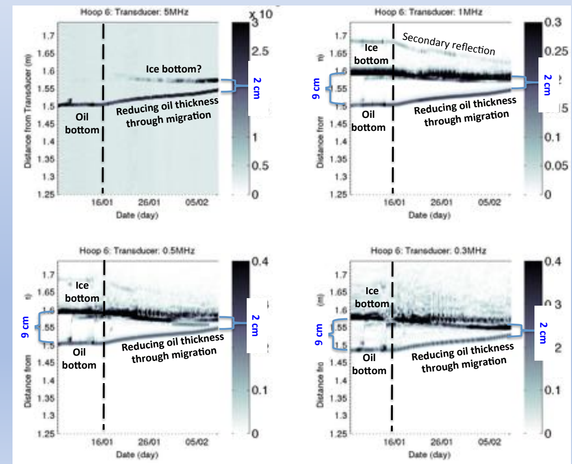
Oil encapsulation: Under growing conditions

Ice growing will encapsulate the oil



Laboratory experiment showing the cross section of an oil-ice sandwich (Izumiyama et al., 2004)

Oil vertically migrates through the ice in the summer.



Sensors that show promise: encapsulated and under ice

Ideally satellite, then airborne, then underwater, then on ice

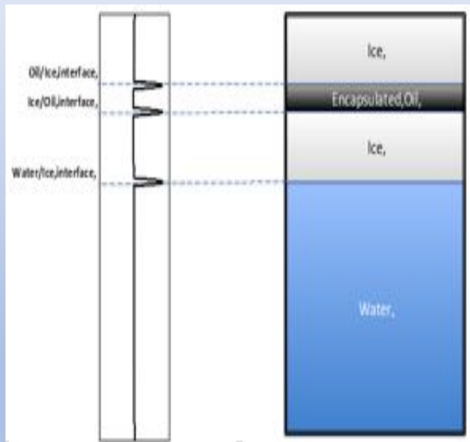
Above-ice sensors include:

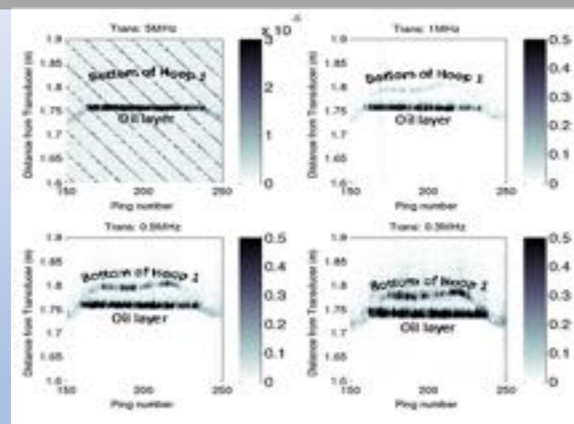
- frequency modulated continuous wave (FMCW) radars,
- ground penetrating radars
- visible and infrared cameras,
- laser fluorescence polarization (FP) sensor.

Below-ice sensors include :

- spectral radiance and irradiance sensors,
- laser fluorescence polarization,
- cameras,
- Acoustics: narrowband, broadband and multibeam

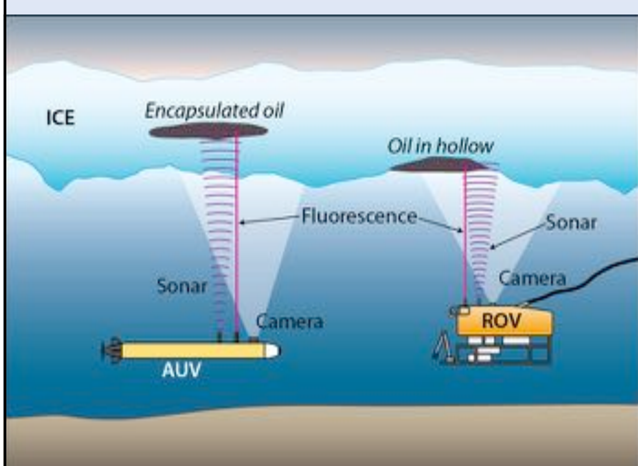
Example of detection technique: sonar





- Positive detection of oil
- Measures thickness of oil
- Detected encapsulated oil (more work needed)

Next steps: under ice



Sensors

- *No silver bullet: mixture of sensor types*
- *Camera, acoustics (sonar), laser fluorometer are most promising sensors*
- *The advantages and limitations of these sensors under different sea ice and oil spill scenarios needs to be established through controlled and repeatable laboratory experiments focussing on sensor signal response both for oil under, and encapsulated, within ice.*

AUV/ROVs

Need to advance capabilities with respect to

(1) vehicle launch and recovery,
(2) navigation in complex ice conditions, and
(3) mission strategies and data telemetry so that transition of research-level AUV technology to easy-to-use operational platforms can be most effective.

Latest findings…

- W. Scott Pegau's report "Detection of oil on-in-and-under ice. FINAL REPORT 5.3"
- Report from Joint Industry Programme on oil spill detection and mapping in low visibility and ice: experimental results
- Mainly level ice test
- Still lots to do…

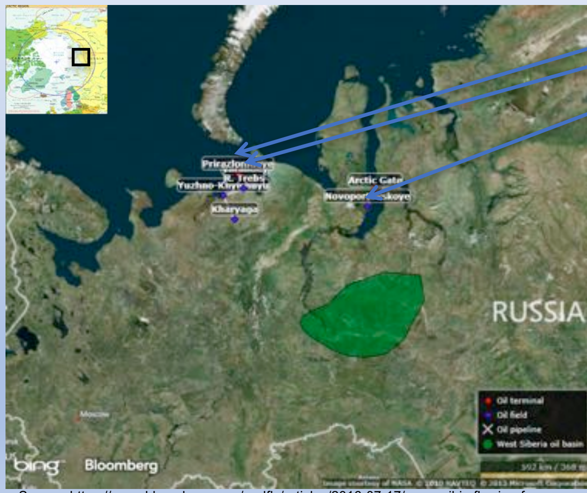
http://www.arcticresponsetechnology.org/research-projects/oil-spill-detection-and-mapping-in-low-visibility-and-ice/research-report

Conclusions

- Window of opportunity
- Made good progress over the past few years, but much needs to be done. Generally only looked at the easiest of cases.
- Build on the programmes that have been performed in the past.
- Above ice systems: ideal system, but still work to be done before it is operational
- Below ice systems: sensors work, but need to push the AUV technology.
- Paris agreement, the world will move away from hydrocarbons so how much drilling will occur in the Arctic. Thus shipping accident probably most likely

Window of a opportunity is open…
But for how long?

Things are changing, and changing fast…. Look at the Russian Arctic for example…



Source: https://www.bloomberg.com/gadfly/articles/2016-07-17/more-oil-is-flowing-from-one-part-of-the-arctic-than-libya

- ❑ These three terminals handled (by ship) a combined 230,000 barrels a day in the second quarter of 2016. The flow of oil has almost doubled from 130,000 barrels in January last year.
- ❑ Production from Russia's new Arctic oil fields could top 400,000 barrels a day by 2020.