ASMA Project- Focus on Submerged oil

http://asma.dhigroup.com/

Project Rationale

Problem definition

In several recent oil accidents in Europe detection and monitoring of spills have been hampered by fast sinking oil

•Leaving no trace at surface the quantification and monitoring of sunken/submerged oil is difficult

•Adequate methods are lacking or has not been tested thorough.

Project Rationale

Examples

Volgoneft 248 (Sea of Marmara, Turkey 1999)

Erika (France, 1999), *Prestige* (Spain, 2002) - Heavy fuel oil has probably travelled for days below the surface or close to the sea bottom without being detectable by the usual means (e.g. aircraft crew visual observation). Presence of submerged oil was occasionally reported by fishermen.

Fu Shan Hai (Baltic Sea, 2004)

Sea Venture II (Great Belt, Denmark, 2005)- Spilled oil may have moved below the sea surface as no oil was observed from either air or sea surface, whereas oil and some 4.000 oil-covered diving birds were observed in different places along a 50 km shoreline.

Project Rationale

Work Packages

WP1 Review existing information from past accidents where submerged oil occurred

WP2 Review and testing the feasibility new techniques to quantify the magnitude, transport and potential impacts of submerged oil spills

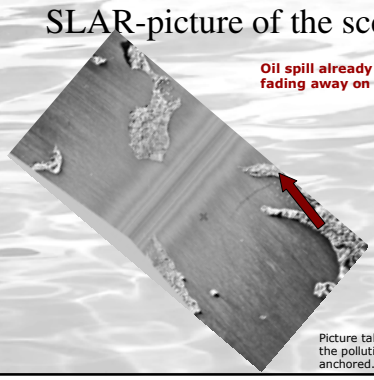
- Task 2.1 Applicability of ocean colour remote sensing data to detect submerged oil
- Task 2.2 Refining acoustic methods to detect and quantify sunken oil
- Task 2.3 Modelling of subsurface oil drift and fate following the Sea Venture II oil spill

WP3 Disseminating of results

Applicability of ocean colour remote sensing data to detect submerged oil Color satellite

Route of the vessel

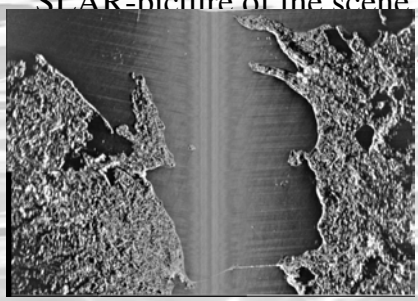
SLAR-picture of the scene



Oil spill already dissolving – fading away on the picture.

Picture taken shortly after the polluting vessel had anchored.

SLAR-picture of the scene



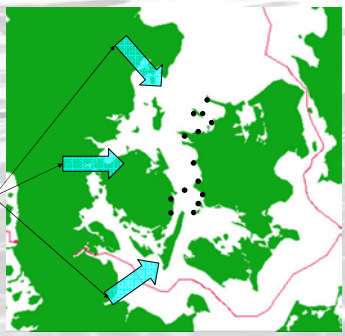
No oil observed.

Picture(s) taken 2 days after the incident.

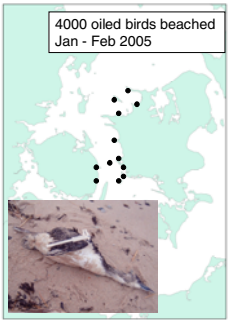
Observations of oily birds and oil on the shore

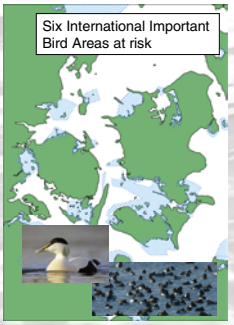
Dates:
JAN 21st
to
FEB 11th.

Sea-Surf:
Water temp:
2˚5 to 3˚5
Wind: ---------
NW to SW
Current:
North / South



Sea Venture II / Impact on wintering waterbirds



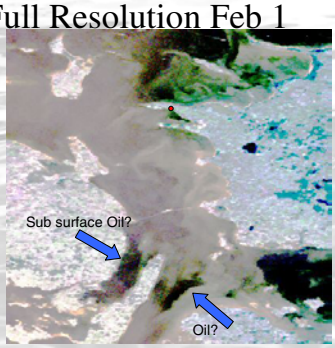


Oil and optical remote sensing

- More than 15 Meris and Modis images for the period January 20 to February 10 were analysed
  - The most are extremely clouded
  - No high resolution remote sensing data were available (no Landsat, QuickBird, Ikonos or SPOT)
- Only one Meris Full Resolution (FR) scene from February 1 was useful
  - Meris FR has 300 x 300 m pixels

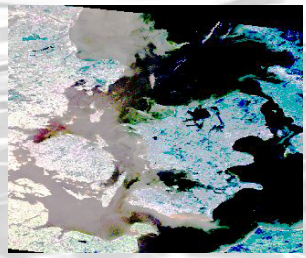
MERIS Full Resolution Feb 1

- Sub surface oil increase the light absorption compared to water
  - Pronounced for short wavelengths
- Consequently, dark areas may be sub surface oil
- Radiance colour composite of band 4 (510 nm), 5 (560 nm) and 6 (620 nm) in red, green and blue
- Simple contrast enhancement of the image has been made



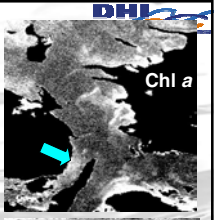
Not much light – difficult light conditions

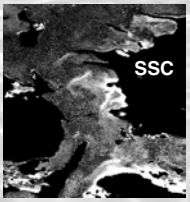
- Recorded at 09:37 UTZ
- Latitude 55° 43'
- Low sun angle on February 1
- There is a clear East – West effect in the image probably caused by the low sun angle
  - This gradient can be seen in both radiance and reflectance images

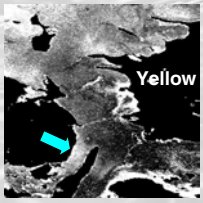


Evaluating associated effects

Maps were made of:
-Chlorophyll *a* concentrations (Chl *a)*
-Suspended Sediment Concentrations (SSC)
-Yellow Substance (Yellow)
Low values are dark, light values are high







NB: The three maps have not been verified but only used for a first qualitative assessment

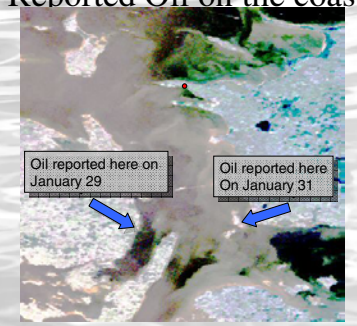
Pro and cons

- Reservations against the identification of sub surface oil spill are:
  - The limited amount of light being reflected from the water body
    - A multitude of effects can cause the dark features
  - Higher concentrations of yellow substance will absorb radiation in low wavelengths
  - Possible influence from absorption by yellow substance and chlorophyll *a* between Funen and Langeland

Pro and cons

- In favour of an interpretation of the sub-surface oil detection are the following observations:
  - January 29, oil is observed in the counties of Gudme and Ørbæk, south of Nyborg.
    - This is an exact match with the presence of the dark feature on the east coast of Funen.
  - January 31, oil is observed at the island of Agersø, south of Korsør
    - A dark feature east of Langeland has it's northern point 5 to 10 km south of Agersø
  - No or very limited absorption from yellow substance and chlorophyll *a* east of Langeland
  - No apparent influence on suspended sediment concentrations

Reported Oil on the coast



Refining acoustic methods to detect and quantify sunken oil

Acoustic monitoring of sunken heavy fuel oil on the seafloor

Main conclusion

Side scan sonar are working away from the vertical (30°- 80°) and in such conditions the oil/sand contrast is rather good (15dB)

These systems when operated at constant altitude could *map large areas* so as to *quickly assess where there could be oil patches* on the seafloor in areas that are supposed to trap the pollutant.

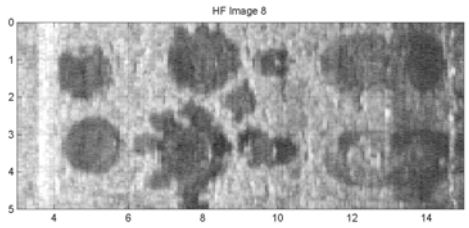
In case of positive results a *closer survey* could be performed by the mean of a front-looking, or better, a 3D Real Time sonar, so as to confirm the diagnostic and decide for a strategy.

The *definitive confirmation* should be *from sampling or close video shots* by means of ROV or AUV (the navigation of which could be facilitated by the use of a 3D sonar)

François Parthiot
Cedre - Delegate for the Mediterranean

Acoustic monitoring of sunken heavy fuel oil on the seafloor

Sidescan SONARS images (DF 1000 at 400kHz)



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Modelling of subsurface oil drift and fate

Modeling of subsurface oil drift and fate following the Sea Venture II oil spill

1. Development of theory for the causal relations determining the fate of the subsurface oil
2. Development of software modeling tool for determining fate of oil in the water environment
3. Validation of theory and software on the Sea Venture II oil spill

Theory for subsurface oil

Possible reasons for subsurface oil

- Heavy fuel oils can have densities up to1.01 kg/L
- Oil can change density in the water environment because oil density is function of
  a) temperature
  b) evaporation of volatile components
  c) water in oil content, that changes as a result of emulsification
  d) Adsorped heavy suspended solids
  - Water density is decreasing for temperatures below 3-4 deg C for fresh and brackish water (<10 psu)
  - Turbulence from waves causing vertical dispersion
  - Source below surface

Theory for subsurface oil

Possible reasons for subsurface oil

Sea Venture II oil spill

- Heavy fuel oils can have densities up to1.01 kg/L — Not the case, 0.95 kg/l
- Oil can increase density in the water environment because oil density is function of
  a) temperature — ✓Yes
  b) evaporation of volatile components — ✓Yes
  c) water in oil content, that changes as a result of emulsification — ✓Yes
  d) Adsorped heavy suspended solids — ?Probably not in this case
  - Water density is decreasing for temperatures below 3-4 deg C for fresh and brackish water (<10 psu) — ✓Yes
  - Turbulence from waves causing vertical dispersion — Could have influence
  - Source below surface — ✓Yes, but right after spill the oil moved to the surface, so not an explanation in this case

Oil spill modeling approach

Precipitation
Evaporation
Boundaries
Wind

→ Hydrodynamic modeling

Salinity
Temperature
Water levels
Curents

Point sources

Forcings:
1. Waves
2. Turbulance
3. Suspended sediments

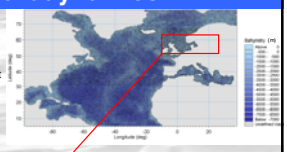
ECO Lab
- Lagrangian oil variable
- Calculates fate of each oil particle

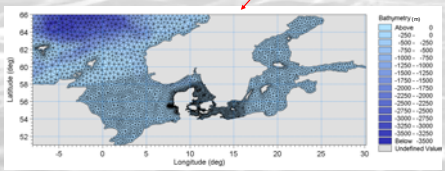
ECO Lab template
User specified equations !!
1. Biodegradation
2. Dispersion
3. Dissolution
4. Sedimentation
5. Buoyancy
6. Spreading
7. Emulsification
8. Evaporation
9. Photolysis
10. Oxidation

→ Oil spill distribution

Oil spill model drift is based on MIKE FM hydrodynamics

Flexible Mesh
- Fine resolution in the areas of interest
- 3D currents
- 3D salinity
- 3D temperature

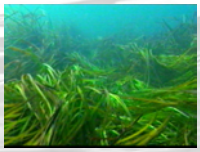




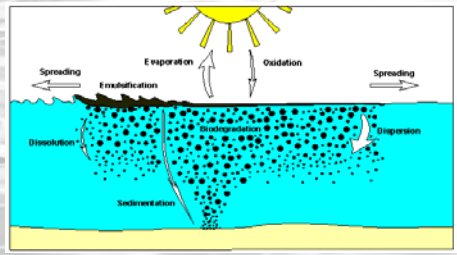
Oil spill weathering is formulated in ECO Lab

ECO Lab is an equation solver with userspecified definitions of state variables and processes

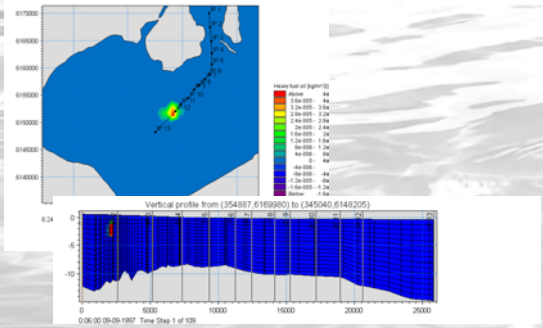
- **Describes chemistry and biology as concentrations in a computational mesh (Euler representation)**
- **Describes lagrangian particles and and processes that affect them (new extension for this project)**



Weathering processes implemented in ECO Lab template



Simulation of spill



View of vertical profile along a horizontal line

New features compared to "traditional" modelling of oil drift

- 3-D modelling to forecast surface drift and submerged oil
- Flexible mesh – the net can quickly be refined near spill and sensitive marine/ coastal areas
- Ecolab (open source in principle) – can quickly be modified to describe weathering of a particular oil.