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Fate and Behaviour of Oil

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Composition of crude oils

- Crude oils are mixtures of many thousands of different hydrocarbons
- Different crude oils have different proportions and therefore different properties
- These range from propane to bitumen
- Other components may include substances such as:
  - Polycyclic Aromatic Hydrocarbons (PAHs);
  - BETX (Benzene, Ethylene, Toluene, Xylene);
  - Heavy metals;
  - Sulphur compounds

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Relevant oil properties

CRUDE OIL ASSAY OR DATA SHEETS

- Density, Specific Gravity, API Gravity
- Volatility - related to boiling point
- Viscosity
- Pour point
- Wax content
- Asphaltene content

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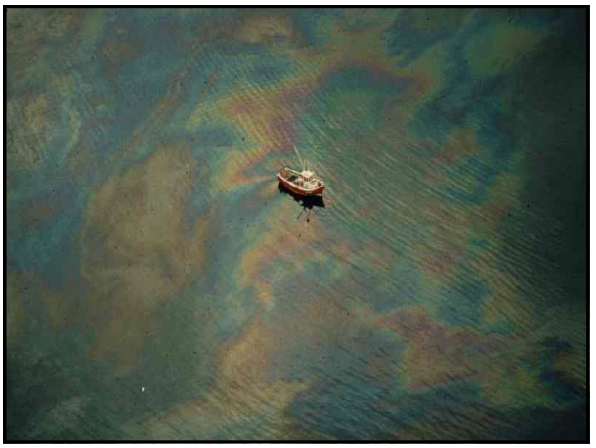

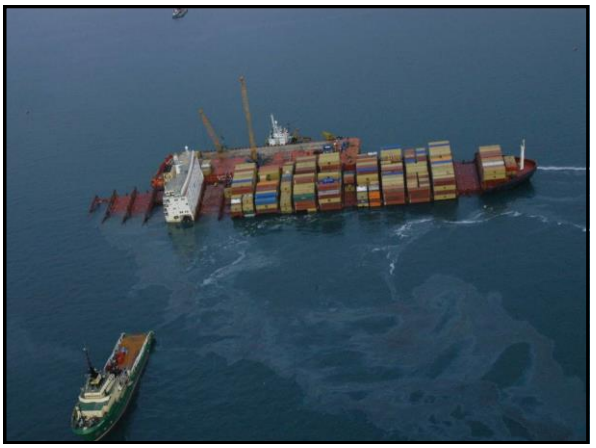

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Fate of spilled oil - Weathering

- Major processes
  - Spreading
  - Evaporation
  - Emulsion formation
  - Natural dispersion
- Other processes
  - Dissolution
  - Oxidation
  - Sedimentation
  - Biodegradation

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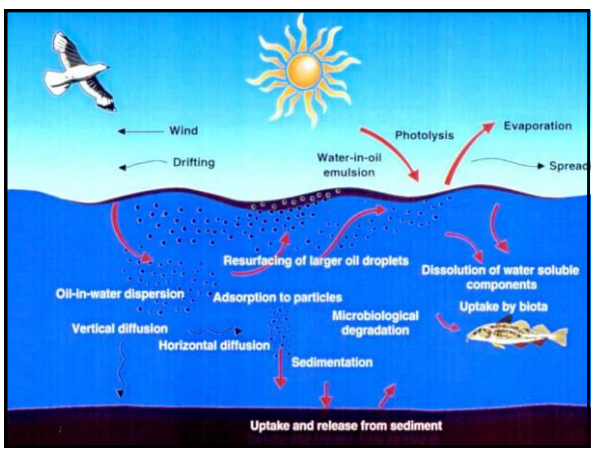

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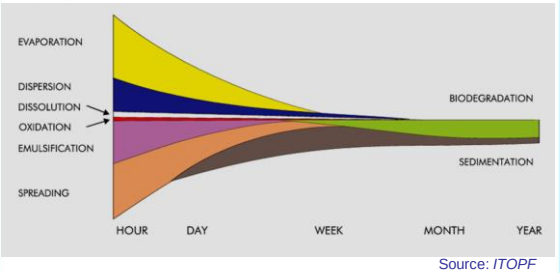
Process with time



Source: *ITOPF*

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Spreading of spilled oil

- Spilled oil floats and spreads out to form an 'oil slick'
  - Very variable thickness from very thin to thick
  - Sheen that is less than 0.1 microns thick
  - Approximate average of 0.1 mm
- 1 tonne of spilled oil will rapidly spread out to a slick with an area of about 10,000 m^2

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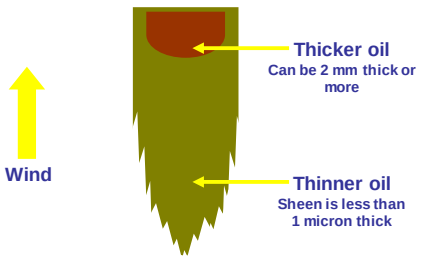
Typical oil slick



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Spreading

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- Rate of spreading depends on viscosity
- Waxy oils break into pieces, rather than spread
- Slicks broken up by wind and currents
- Form 'windrows' parallel to wind direction

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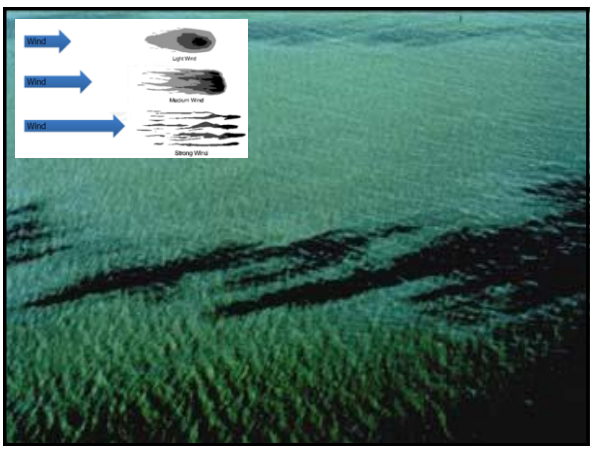

Evaporation of volatile oil components

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More volatile components; gasoline, kerosene

Oil

Water

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Evaporation

- Volume of oil on the sea surface decreases depending on:
  - Oil composition
  - Temperature
  - Wind speed

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Consequences of evaporation

- As the gasoline evaporates the residue contains more of the high viscosity components
- The viscosity of what is left behind increases
- The oil becomes thicker and more sticky

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Natural dispersion

- Natural dispersion requires breaking waves
  - Not a significant process in calm seas
  - Proceeds more rapidly in rough seas
- If natural dispersion continued to completion all the spilled oil would eventually be naturally dispersed and there would be no need for oil spill response

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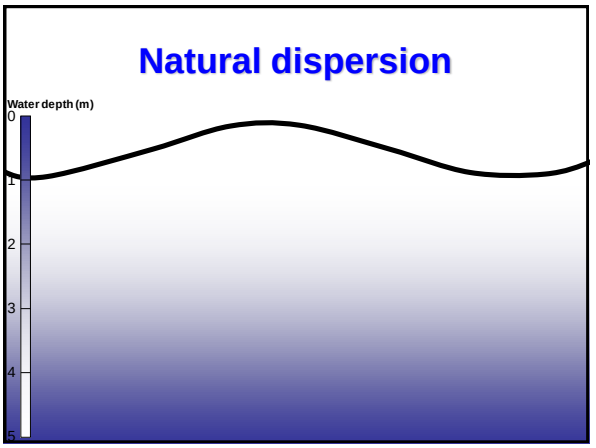
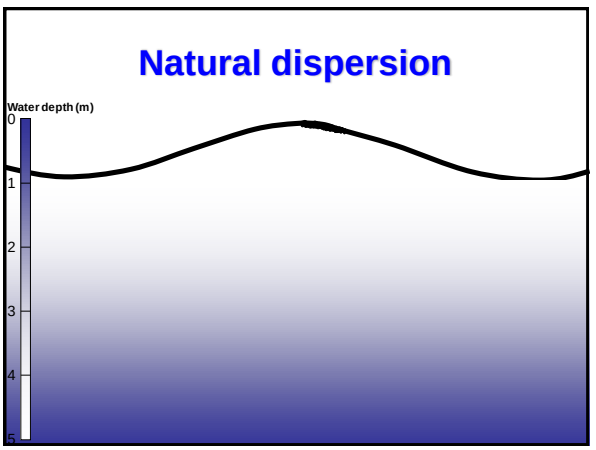
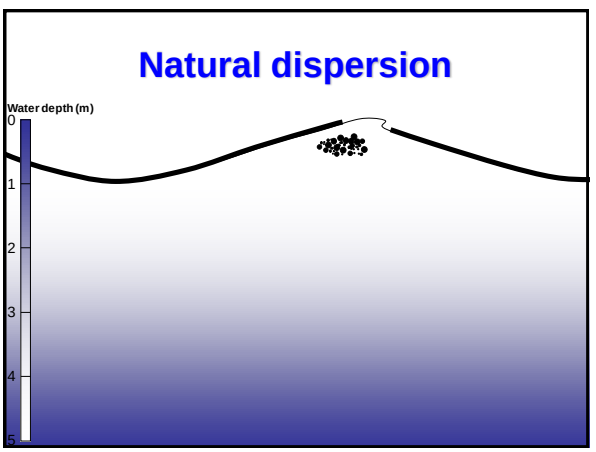
Natural dispersion



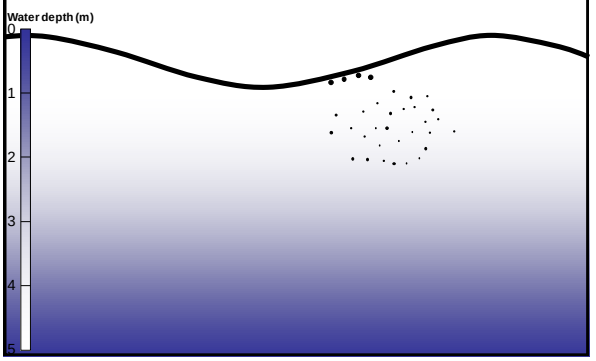
Natural dispersion



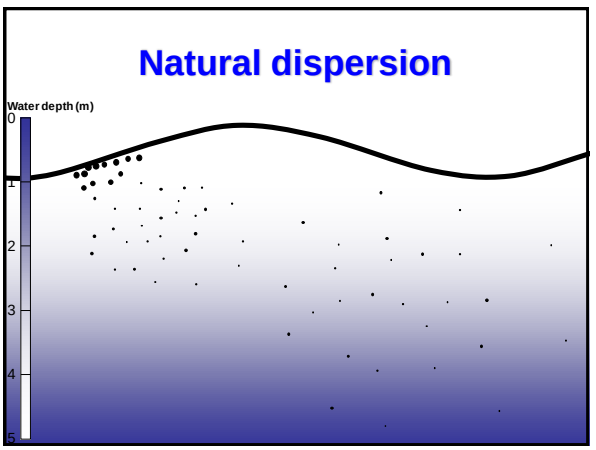
Natural dispersion



Natural dispersion



Natural dispersion



Water-in-oil emulsification

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- Water droplets can become incorporated in the body of oil
- Asphaltenes help this emulsification process

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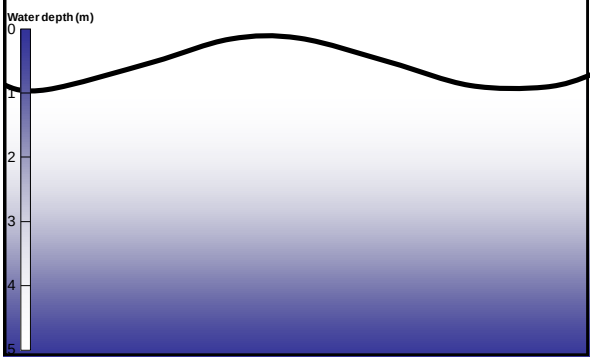
Water-in-oil emulsification



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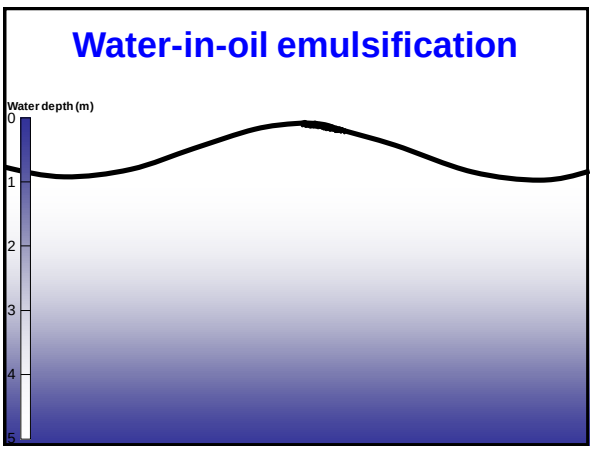

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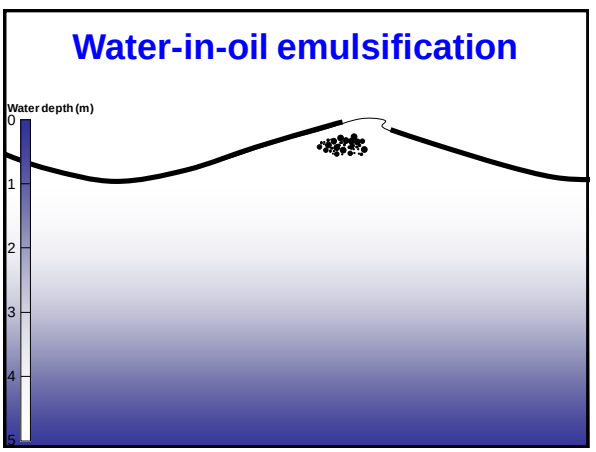

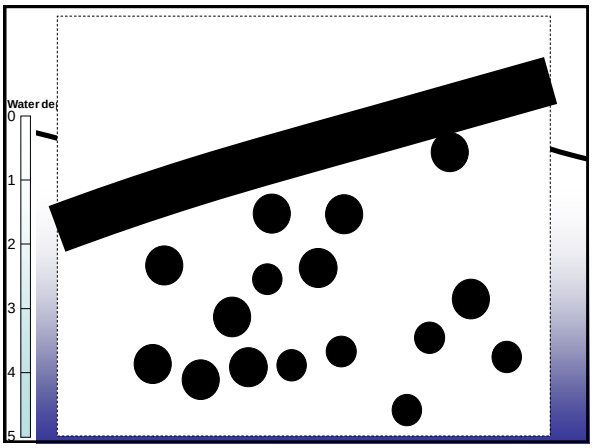
Water de
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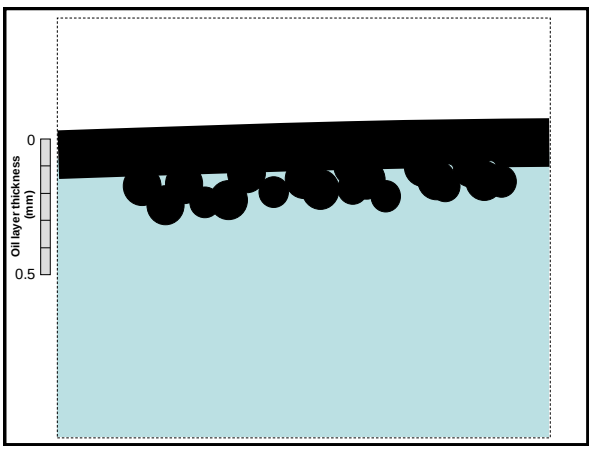
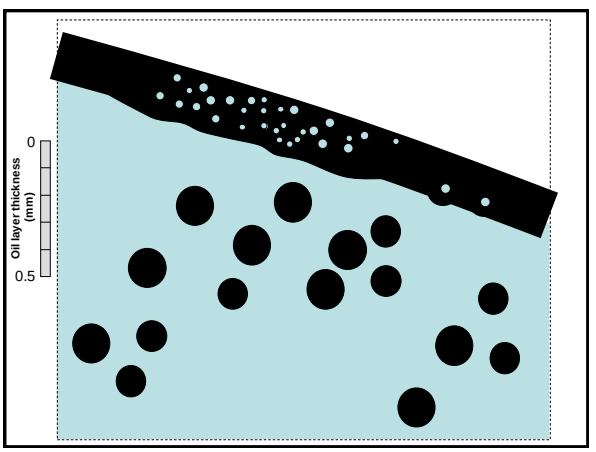
2
3
4
5


Oil layer thickness (mm)
0
0.5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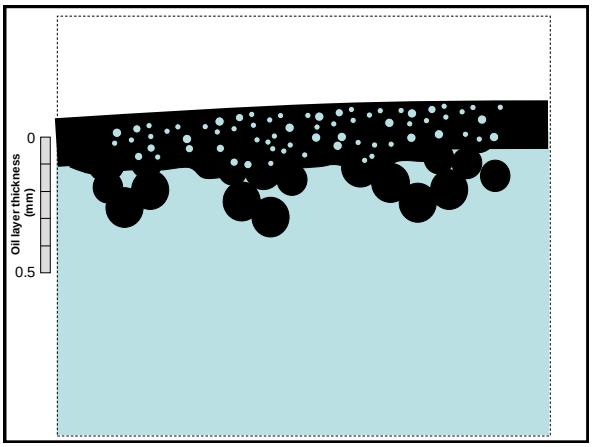
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Oil layer thickness (mm)
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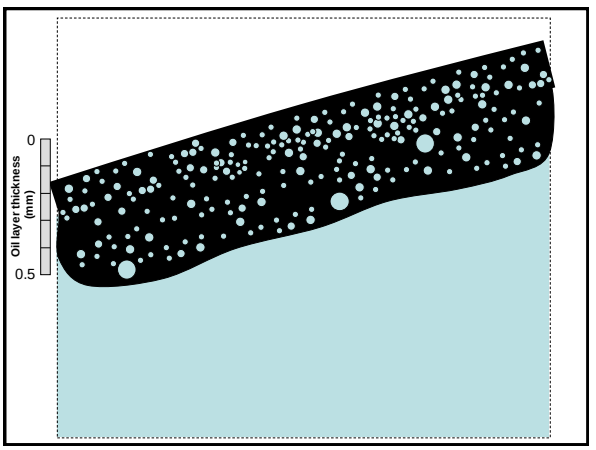
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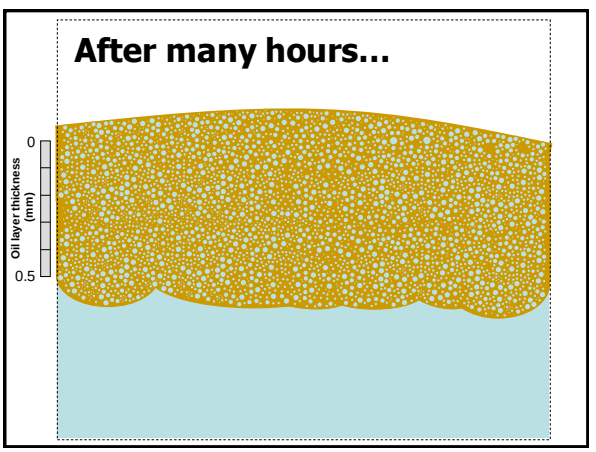
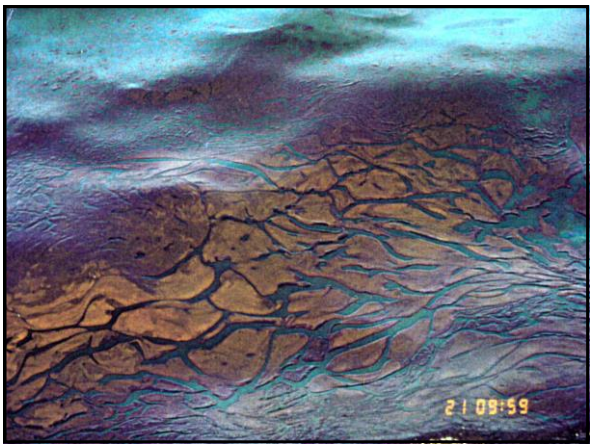
Oil layer thickness (mm)
0.5


After many hours...
0
Oil layer thickness (mm)
0.5



Consequences of emulsification

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- Up to 75% volume of water
- Volume of the emulsified oil is 4 times that of residue left after evaporation
- Emulsified oil is much thicker (higher viscosity) than that of oil that was spilled

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An example

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- 1,000 tonnes of a light crude oil spilled
  - Spreads out into a slick with an area of approximately 10 km^2 (10,000,000 m^2).
  - 900 tonnes will be in 1 km^2
  - Approximately 30% (300 tonnes) will evaporate in 24 hours leaving 700 tonnes
  - Remaining oil will incorporate water to produce 2,800 tonnes of emulsified oil
- 1,000 tonnes spilled, 2,800 tonnes formed

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Other processes

- Dissolution
  - A few oil components dissolve in water
- Oxidation
  - Sunlight and air cause oil to change
- Biodegradation
  - Micro-organisms ‘eat’ oil if it is dispersed
- Sedimentation
  - If there is suspended sediment

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Spilled oil movement

- Oils slicks drift
  - With the current at the speed of the current
  - In the direction of the wind at 3% of wind speed

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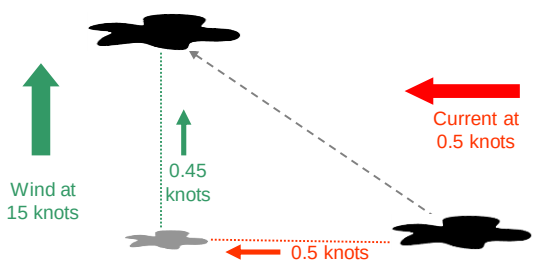
Effect of current and wind



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Computer models predict:

- Oil spill movement:
  - Tidal databases and wind direction and speed input
  - Slick trajectory output
- Oil 'weathering' properties:
  - Oil specific inputs
  - Increase in emulsified oil viscosity output
  - Increase in emulsified oil volume output

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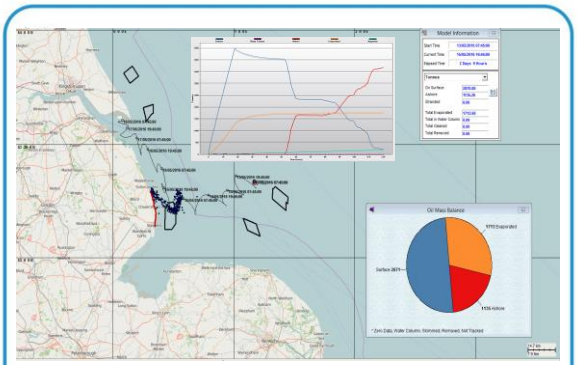

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Oil that comes ashore

- Oil that comes ashore becomes mixed up with seaweed, sand etc.
- Great care is needed to prevent picking up a lot of beach material with the oil
  - Best practice will mean oily material contains 25% - 30% oil
  - Bad practice can results in 10% or less oil picked up

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Shoreline clean-up volumes

- 1,000 tonnes of a light crude oil spilled
- 2,800 tonnes emulsified oil comes ashore
- Amount of oil to be disposed of varies:
  - 10,000 tonnes of oily material recovered with best practice
  - 30,000 tonnes of oily material recovered with poor practice

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