The Density Behaviour of Heavy Oils in Freshwater

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Overview

- Review of basics
- The Wabamun spill
- Mechanisms by which oil becomes heavier
- Mechanisms by which oil becomes lighter

Definitions

- Sinking – oil moves to at least 1 metre depth – usually to bottom or pycnocline (salinity phase)
- Over-washing – a thin layer of water covers the oil, generally under some wave conditions – oil may not be visible except at oblique angles

What causes Sinking or Over-washing?

- Increase in oil density or a high initial density
- Oceanographic conditions – especially vertical mixing and density differences
- But in freshwater, the concerns become largely sinking

The Wabamun Spill – An Example of Heavy Oil in a Freshwater Lake

- At 10:00 August 6 Canadian National Railways had a derailment on their main east-west line through the town of Wabamun, on Lake Wabamun, spilling a total of about 800,000 litres of heavy fuel oil (Bunker C) and about 90,000 litres of lube oil (then stated) (11 + 1 cars out of about 15 tankers, about 70 total)

Lake Wabamun

- Is close to Edmonton and several persons with cottages (houses) work in Edmonton
- Has 4 huge power plants nearby – 2 directly on lake
- Is complicated by having a village, two power plants, an Indian reservation, a rail line and public beaches – all in close proximity
- Is about 8 miles long and about 2 miles wide


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Heavy Oil Behaviour -Overview

- As oil was heavy fuel oil and flowed over land to get to the water, some of it picked up sediment
- Several phenomena observed: oil re-surfacing, neutrally-buoyant tar balls, oil on bottom, daily re-oiling of shoreline – even after bulk oil skimmed

Specific Observations

- Sometimes very big lumps of tar – called tar logs here
- These objects range from 6 to 20 cm in diameter and from 1 to 5 m in length (for USA about 2 to 10 in in diameter and from 4 to about 15 feet in length)

Specific – 2

- Often a lot of tar balls were present in near-shore areas
- Tar balls typically were 2 to 10 cm in diameter
- With wind, positions of these changed


Arrows point to some of the many tar balls on bottom

Specific - 3

- Many of the tar balls were mobile and would move around and change location around the various beaches
- Many of the tar balls were almost neutrally buoyant

Specific 4

- Extensive oil in the reed beds
- Some of this oil rose during the day
- Oil in the reed beds did not appear to be as mobile as other tar balls

Specific 5 - curiosity

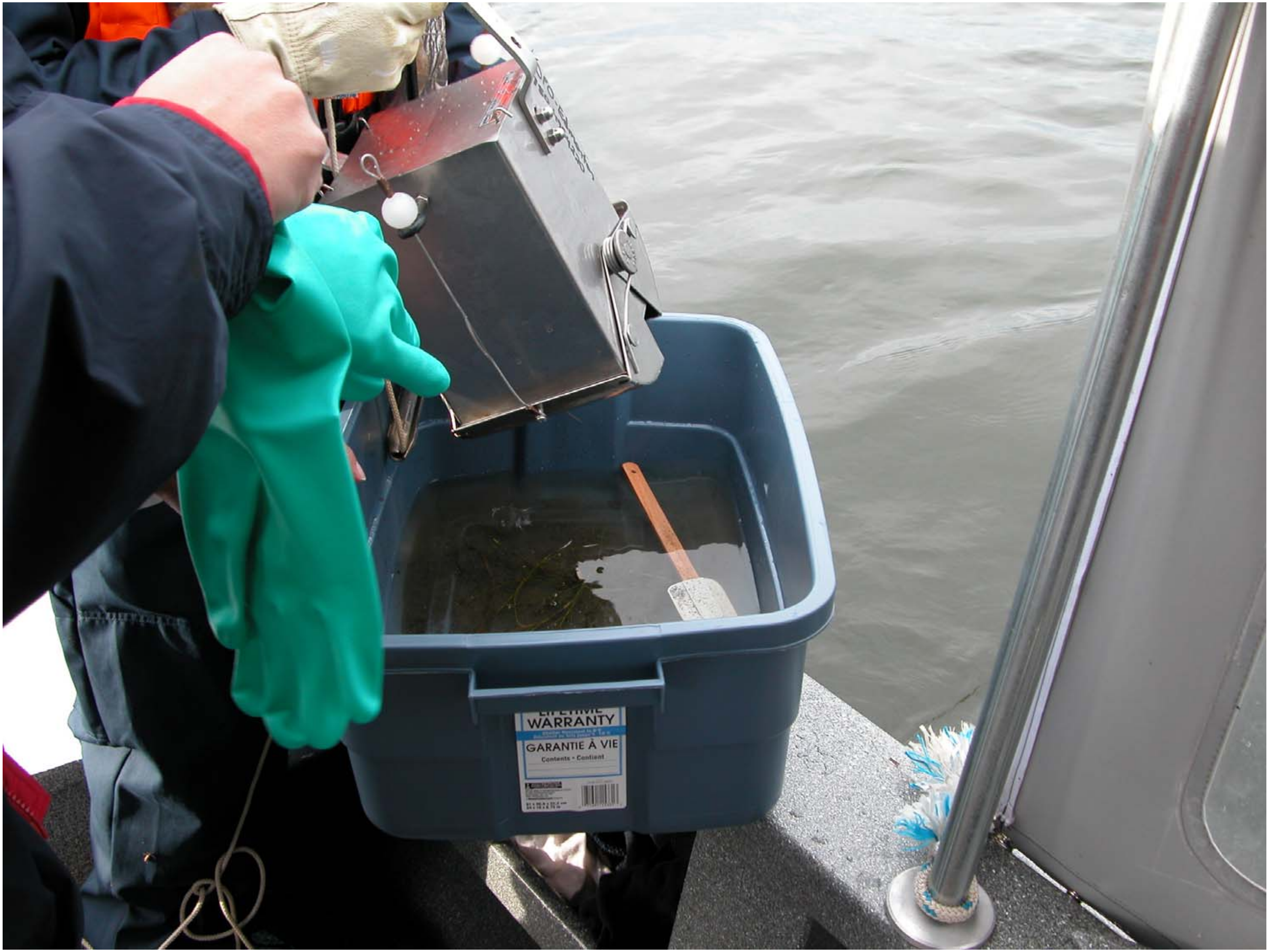
- Tar balls re-surfacing – would sometimes shed oil in a strange way
- Oil would come from several openings in the tar ball
- Appeared like a new strange creature

Specifics - 6

- Tar mats were often on the bottom in near-shore areas
- Some of the material became mixed with rubble and organic material
- Tar mats seemed to be immobile and were largely removed manually during the cleanup operation

Specifics - 7

- There was oil on the bottom in deeper areas – particularly near the spill site
- Sheens appeared above this area daily
- During an ice survey in winter, small tar balls were found under the ice in this area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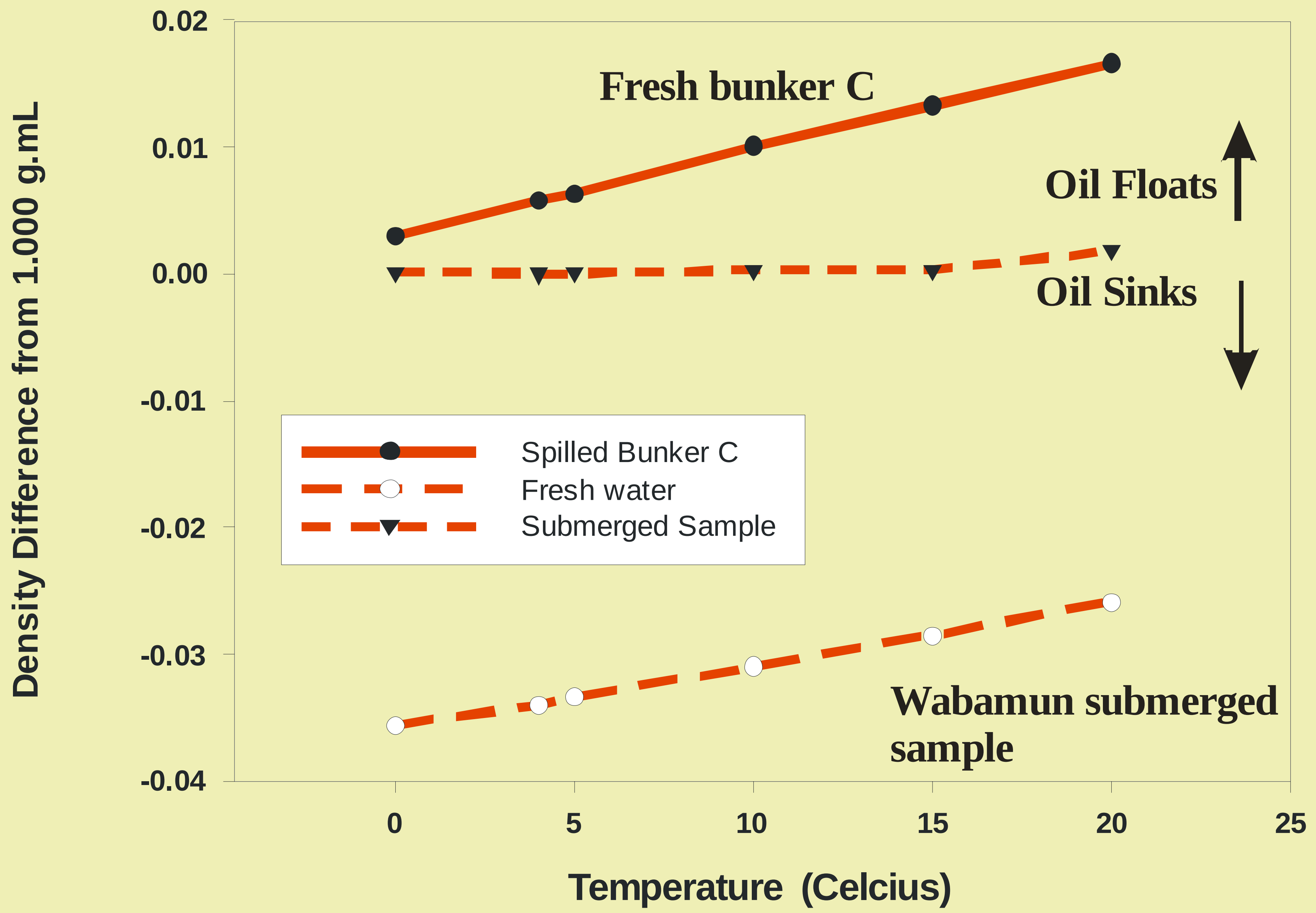
Mechanisms that make oil more dense

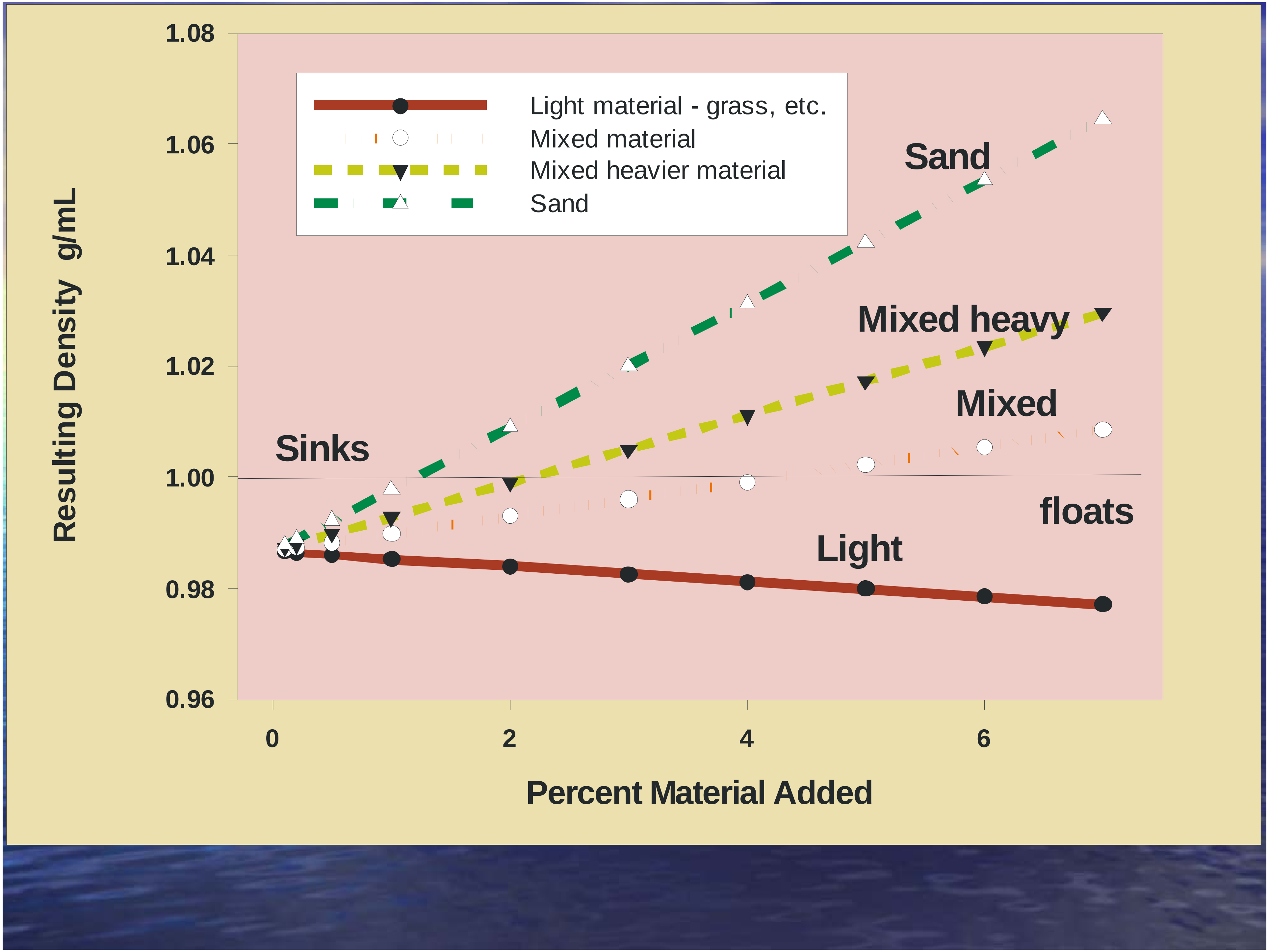
- Evaporation – loss of lighter material can make the oil more dense
- Temperature change – oil changes density faster than water with temperature change



0.02
0.01
0.00
-0.01
-0.02
-0.03
-0.04
Density Difference from 1.000 g.mL
Fresh bunker C
Oil Floats
Oil Sinks
Spilled Bunker C
Fresh water
Submerged Sample
Wabamun submerged sample
0
5
10
15
20
25
Temperature (Celcius)

More sinking mechanisms

- Uptake of solid material
- Many historic spills showed at 2 to 3% uptake of sediment is sufficient to sink oil
- A ‘new’ mechanism noted at Wabamun – uptake of lighter material (grass, insects) that lose air and uptake oil to become heavier and thus this change may be sufficient to sink oil



Light material - grass, etc.
Mixed material
Mixed heavier material
Sand
Sand
Mixed heavy
Mixed
Sinks
floats
Light
Resulting Density g/mL
Percent Material Added
1.08
1.06
1.04
1.02
1.00
0.98
0.96
0
2
4
6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Mechanisms by Which Oil Resurfaces

- Loss of solid matter

    - break up of mat/log – break occurs along less-viscous areas and oil flows out

    - downward movement of particles

    - sloughing-off of surface

    - Break-through of oil through cracks

Mechanisms that resurface oil

- Changes in temperature or water hardness (must have oil very near floating to have this happen)
- Uptake of lighter material – could actually decrease density – given that this material does not lose air or become wetted


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Summary

- Interesting bahaviour of oils in freshwater systems can be explained
- Major effect is uptake of sediment, sand and material more dense than water
- Major re-surfacing is due to the loss of this material – or oil escaping from the adsorbed mass


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