Non-floating Oil Effects on Natural Resources

April DaSilva

Natural Resource Damage Assessment Unit

CDFW-OSPR

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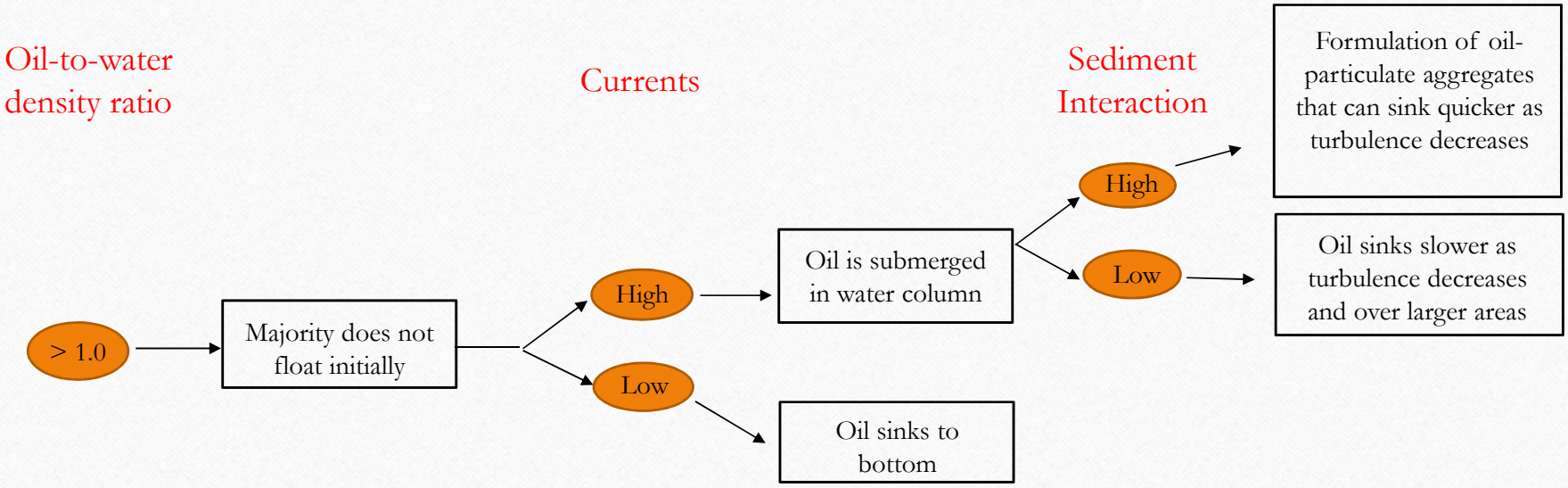
Oil Types

Group 1	Group 2	Group 3	Group 4	Group 5
Very Light	Light	Medium	Heavy	Non-floating
Gasoline Jet Fuels	Diesel No. 2 Fuel Oil Kerosene Light Crudes	Alaskan North Slope Crude Medium Crudes	Bunker C No. 6 Fuel Oil Residual fuels Heavy Crudes	Coal Tar Oils Asphalt Very Heavy Crudes
SG < 0.80	SG = 0.80 – 0.85	SG = 0.85 – 0.95	SG = 0.95 – 1.00	SG > 1.00
Impacts to water column and intertidal resources	Impacts intertidal resources	Impacts to intertidal resources, water fowl and fur-bearing mammals	Heavy contamination to intertidal resources, water fowl and fur-bearing mammals, long-term sediment contamination	Long-term sediment contamination

Non-floating Oil Concept



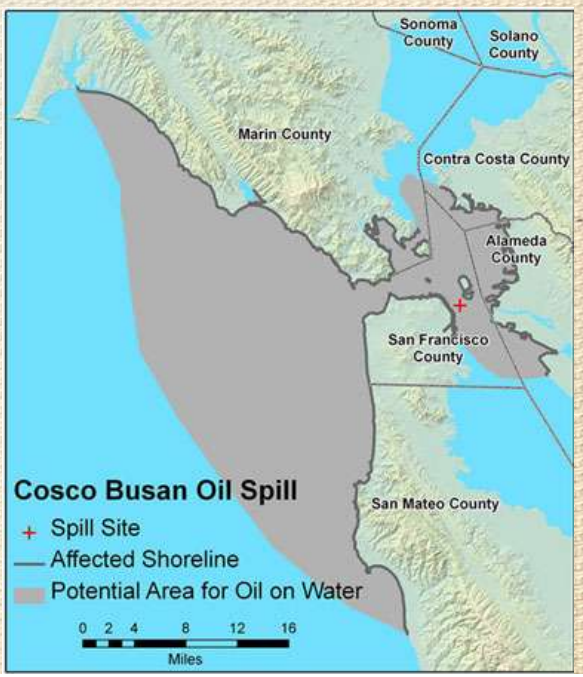
Committee on Marine Transportation of Heavy Oils et al., (1999) Spills of Nonfloating Oils Risk and Response. Chapter: 2 Behavioral Models and the Resources at Risk. https://www.nap.edu/read/9640/chapter/1

Non-floating Oil Risks

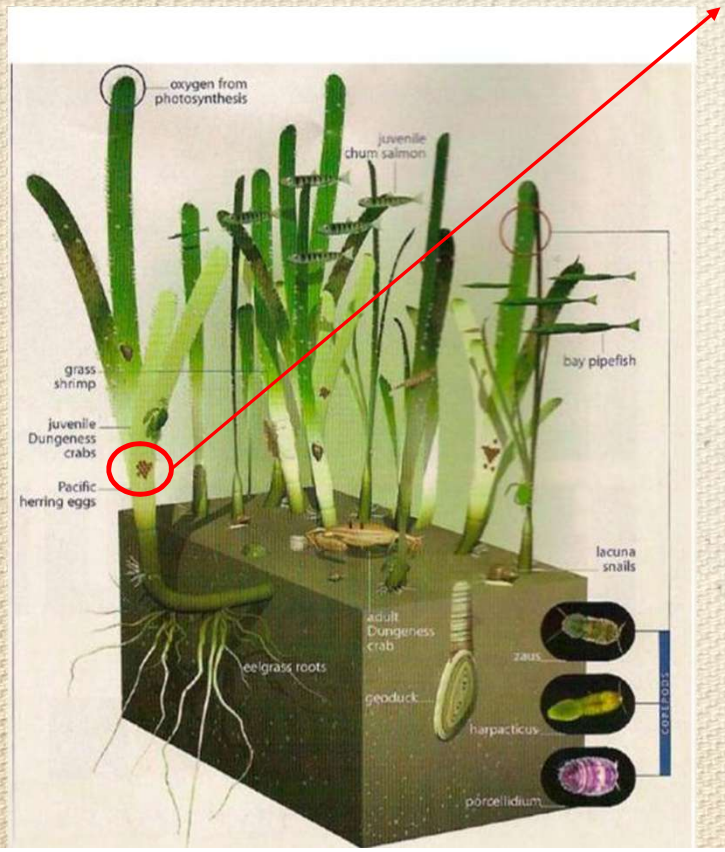
- Oil accumulates on a waterbody's bottom
- Slow weathering
- Slow release of water-soluble PAHs
- Increased risk of chronic exposure
- Smothering and coating expected
- Benthic organisms (shellfish, fish, macroinvertebrates etc.) at highest risk of exposure
- Possible resuspension into the water column

Cosco Busan Oil Spill – San Francisco Bay

- November 7, 2007
- Marine spill
- Bunker/Intermediate Fuel oil
- Impacted eelgrass beds and Pacific Herring spawning habitats
  - eelgrass grows in the intertidal zones from 2 – 5m deep
  - Pacific Herring spawn adheres to eelgrass



Adverse effects

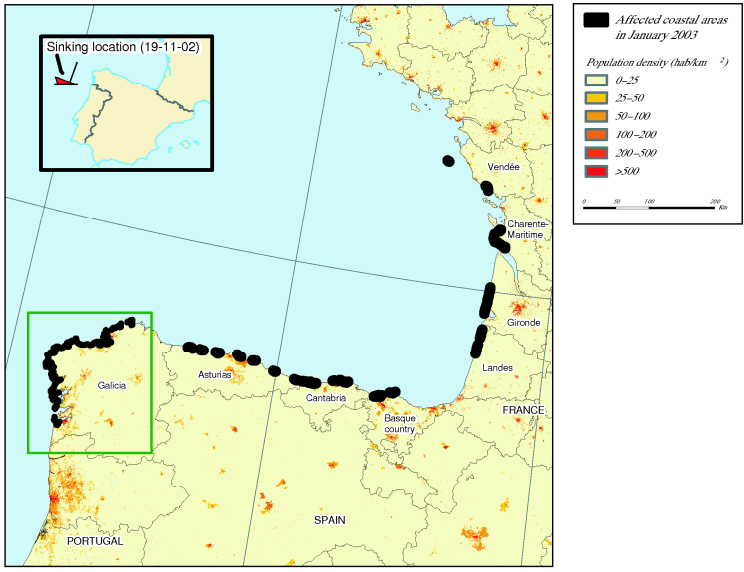


- Coat aquatic plants
- Effects on Early-life stages
  - Egg mortality
  - Reduced hatching
  - Developmental defects
  - Pericardial and yolk sac edema
  - Spinal curvature
- Lost production of viable larvae for next spawning season

- Incardona et al., (2011) The 2007 Cosco Busan oil spill: Field and laboratory assessment of toxic injury to Pacific herring embryos and larvae in the San Francisco estuary.

Prestige Oil Spill – NW Spain

- November 2002
- Marine spill
- Heavy fuel oil
- Tanker sank to ~4000m deep
- Oil was dispersed and sank due to bad weather and wave action
- Tar aggregates dropped out of the water column and were found one month later on the seabed



Adverse effects

- Long residence time due to depth
- Benthic species effects[2]
  - Oil found in exoskeletons and the gut of zooplankton species
  - Suprabenthic amphipods were found to be stained with oil
  - Reduction in growth and food consumption among juvenile benthic fish (lab study)[1]
- Ecosystem effects[2]
  - Effects on secondary producers, suspension feeders, and detritivorous organisms
  - Bottom-up effect – shifts in abundances in lower trophic levels
  - Top-down effect – possible enhancement in the biomass of predators

[1] Martinez-Gomez et al., (2006) Monitoring biomarkers in fish (Lepidorhombus boscii and Callionymus lyra) from the northern Iberian shelf after the Prestige oil spill. Marine Pollution Bulletin 53: 305–314.

[2] Serrano et al., (2006) Spatial and temporal changes in benthic communities of the Galician continental shelf after the Prestige oil spill. Marine Pollution Bulletin 53: 315–331

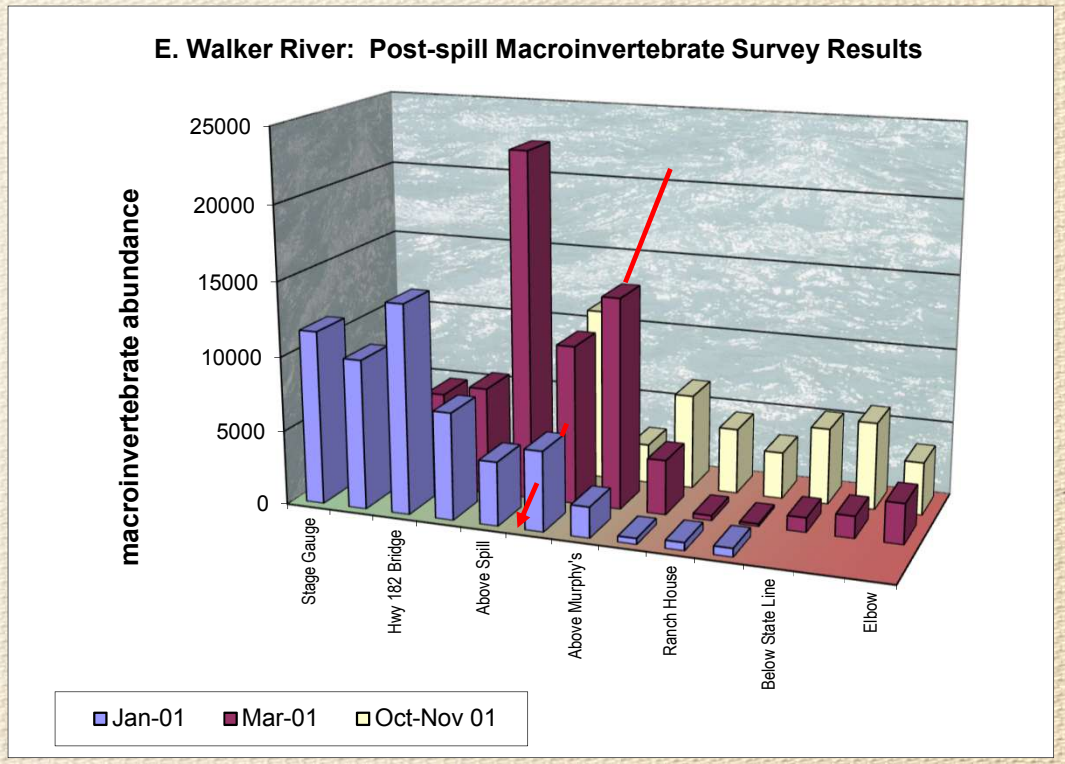
East Walker River – Mono County, CA

- December 30, 2000
- Freshwater Spill
- No. 6 Fuel Oil – becomes tar-like at low temperatures
- January 2001 was exceptionally cold
  - low temperatures averaging 9°F,
  - severe winter weather forced temps. below zero

Adverse effects

- Reduction in macroinvertebrates[1, 2]
  - Recovered BMI were oiled in tar-like material covering head, mouth, abdomen, thorax, legs and cerci
  - Reduce feeding capabilities
  - Restrict movement
  - Increase vulnerability to predation

- Fish mortality[2]
  - Reduction in food supply
  - Direct PAH exposure
  - Formation of anchor ice in the river



[1] CDFG Aquatic Bioassessment Lab (2006) Biological and Physical/Habitat Assessment Report in Response to an Inland Waters Pollution Spill.
[2] Hampton et al., (2002) Assessment of Natural Resource Damages As a Result of the East Walker River Oil Spill On December 30, 2000.

Enbridge Oil Spill - Kalamazoo River, Michigan

- July 26, 2010
- Freshwater spill
- Diluted Bitumen (dilbit) – heavy asphalt-like crude
- Initially floated then sank after loss of volatile fraction
- Submerged oil and oil-contaminated sediment removed by dredging (~12-18,000 gallons)
- Sunken oil remobilized due to changes in turbulence and currents
- Sampling efforts produced surface sheens when depositional zones were disturbed

Aquatic Macroinvertebrate Study[1]

- reduced diversity and abundance of macroinvertebrates
- In 2011, scores improved, but abundance was still impacted.
- Decrease in vegetative cover exposed more of the stream
- Altered macroinvertebrate community composition due to increased instream sunlight

Adverse effects[1, 2]

- Removal techniques removed aquatic vegetation and roots
  - Increase vulnerability to predation
- Burial/Smothering of the fish and benthic zone
  - Direct mortality
  - Dissolved oxygen depletion
  - Abrasion of fish gills
  - Chronic exposure leading to adverse effects on reproduction, development, immunity
  - Gross examination of fish showed hemorrhages, skin lesions, and skin irritation
  - Reduction in BMI biomass and growth

[1] Winter et al., Assessing Natural Resource Impacts from the Enbridge Pipeline Spill into the Kalamazoo River. *Presentation.*
[2] Fitzpatrick et al., (2012) Net Environmental Benefit Analysis (NEBA) Relative Risk Ranking Conceptual Design. Kalamazoo River System Enbridge Line 6B MP 608 Marshall, MI Pipeline Release.

Summary

- Submerged/sunken oil may reside longer in the sediments due to slow weathering, density, and viscosity
- Studies have shown:
  - Reduction in benthic communities due to contaminated sediments
  - Physical malformations on bottom dwelling fish species
  - Reduction in food supply
  - Mortality
- Long-term chronic impacts include:
  - Reduction in reproduction and development
  - Tumors
  - Mortality
- Ecosystem effects:
  - Bottom-up effect – shifts in abundances in lower trophic levels
  - Top-down effect – possible enhancement in the biomass of predators that affect lower trophic levels