Mapping the penetration and retention potentials of two weathered diluted bitumen oils for the shorelines of Northern British Columbia, Canada

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ABSTRACT

#208 With the increase in bitumen production from Alberta's oil sands, there is a related increase in the transport of non-conventional crude oils throughout Canada, including proposed pipeline projects to carry diluted bitumens (dilbits) to facilities on the East and West coasts of Canada. While the behaviour of conventional oil is well known, little information is available regarding the fate of any potential dilbit spills on marine shorelines. In this study, we aim to develop tools to help oil spill responders to predict the fate of dilbit on the shorelines of Northern British Columbia (BC). To address this objective, we collected data from three sources: segmentation of the upper intertidal zone of the Douglas Channel and Haida Gwaii Island, BC, particle size analysis results of sediment samples collected directly from Northern BC shorelines, and meso-scale laboratory research results on the penetration and retention of dilbit in different types of sediment. This last experiment was conducted in laboratory by an external contractor (Coastal and Ocean Resources Inc.) to estimate penetration (cm) and retention (% of the loading) of two weathered dilbits (Access Western Blend [18% mass loss] and Cold Lake Blend [15% mass loss]) in different sediment types and sizes (from coarse sand to very large pebbles). These data were compiled to associate each shoreline type with dilbit penetration and retention numerical values. For each shoreline type, we performed a quantitative (penetration) and qualitative (retention) estimation of dilbit properties. The estimations were also visually represented on ArcMap 9.1. In Northern British Columbia, it was determined that a large portion of the shoreline is associated with low penetration and low retention that correspond to the abundance of bedrock substrate. Conversely, high penetration and retention is mainly associated with coarse sediments (i.e. pebble/cobble beaches), as well as in sensitive shorelines like marshes. Therefore, these data can be used as an operational tool to establish protection-up priorities based on shoreline sensitivity (retention maps), as well as to determine the best strategy for the shoreline cleanup methods (penetration maps).

INTRODUCTION AND OBJECTIVES

- With the increase in augmentation of bitumen production from Alberta's oil sands, several pipeline projects have been proposed to export diluted bitumen (dilbit) (70% bitumen and 30% condensate) across Canada.

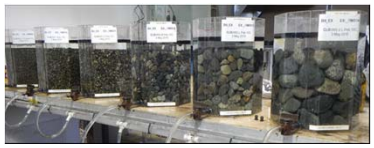
(CAPP 2016)

- Although the composition of conventional petroleum and its physical and chemical properties are extensively studied, little information is available on the potential weathering of dilbit in the marine environment and its behaviour in shoreline sediments (Environment Canada, 2013). With the growth in diluted bitumen exports, many concerns have been raised about the potential environmental consequences of a dilbit spill on marine shorelines.
- To address these gaps in the literature, the current studies focus on the behaviour of dilbit and its potential impacts on the shorelines in Northern British Columbia (BC) (Laforest et al., 2015).
  - ➢ One of the objectives is to develop tools to estimate the potential of dilbit penetration and retention on marine shorelines by establishing a clear link between shoreline segmentation and laboratory studies of dilbit behaviour.
  - ➢ This focus of this paper is mapping information using the results for Access Western Blend [18% mass loss] and Cold Lake Blend [15% mass loss]. These evaporative states were selected as best representative of the state of an spilled oil impacting the coastline.

METHODS

- Shoreline segmentation: 6000 km of shorelines were aerial surveyed in the Douglas Channel and Haida Gwaii between 2013 and 2015. The channel was divided into 8,651 segments, which ranged from 200 to 2000 m in length.
- Ground level surveys: 27 sites were visited in northern BC in 2014 and 2015. At each site, the type of substrates, biodiversity, beach profiles, particle size analysis, and logistical considerations in the event of spills were documented.

- Laboratory experiments were conducted by Coastal and Ocean Resources Inc. to estimate penetration (cm) and retention (% of the loading) of dilbit in different substrates (Harper et al., 2016). They used two moderately weathered dilbit products, Access Western Blend (AWB) and Cold Lake Blend (CLB).

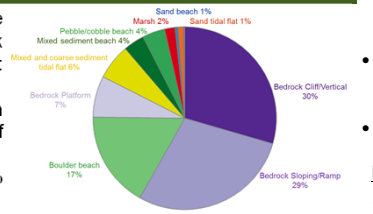


Parameters of the experiment:
- AWB [18% of evaporation]
- CLB [15% of evaporation]
- Marine water (10ºC, 30.9 ppt)
- Coarse sand to very large pebbles
- ~500 g of oil deposited on water surface
- Simulated low and high tides (3h dry followed by 1h oil submergence period)

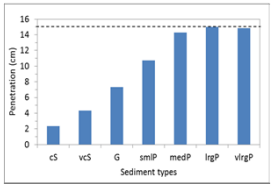
- Based on the data collected and information gathered from the literature, approximate estimates have been established and mapped to determine the penetration and retention of dilbit in each type of shoreline.

FINDINGS

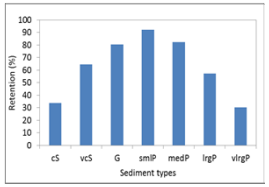
- In Northern BC, a large portion of the shoreline is associated with bedrock substrate (65%). Coarse sediment represents only 14% of the shoreline.
- Mixed sediment beaches are, on average, equal (50%) proportions of sand and 50% gravel.
- Pebble/ cobble beaches are 30% sand and 70% gravel.
- In laboratory, penetration increases with the size of sediment
- Maximum retention is observed with the smallest sediment size (i.e. retention is highest in the small pebbles)



Penetration



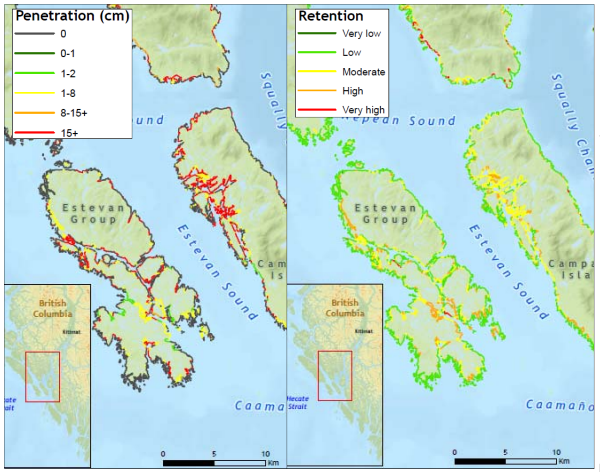
Retention



Legend: course sand (cS), very course sand (vcS), granules (G), small pebbles (smlP), medium pebbles (medP), large pebbles (lrgP), very large pebbles (vlrgP)

DISCUSSION AND NEXT STEPS

- In Northern British Columbia, most of the shoreline is associated with low penetration due to the low permeability of bedrock substrate. Conversely, high penetration is mainly associated with coarse sediments, like pebble/cobble beaches.
- Although marshes and vegetated zones are characterized by very low penetration, dilbit can be expected to readily adhere to substrate surfaces. So, high retention is a characteristic of coarse sediments as well as of sensitive shorelines.



- In the event of an oil spill in the coastal environment in this region, these maps can provide an index of the magnitude of oil penetration and retention in sediments for each type of shoreline concerned.
- However, certain characteristics specific to given shoreline types, as well as inter-segment heterogeneity must be taken into consideration.

Next steps:
- ➢ Additional laboratory experiments using mixed sediments to better estimate the behaviour of dilbit in shorelines with mixed sediment composition.
- ➢ Work to define and consider adhesion of oil to sediment
- ➢ Segmentation and ground surveys for the priority areas in the region of Chedabucto Bay (Nova Scotia) and Bay of Fundy (New Brunswick).
- ➢ Apply this same methodology to priority areas and continue to develop operational tools to improve responses in case of dilbit spills.

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