Chemical Dispersants: Effectiveness in Reducing the Impact of Marine Oil Pollution

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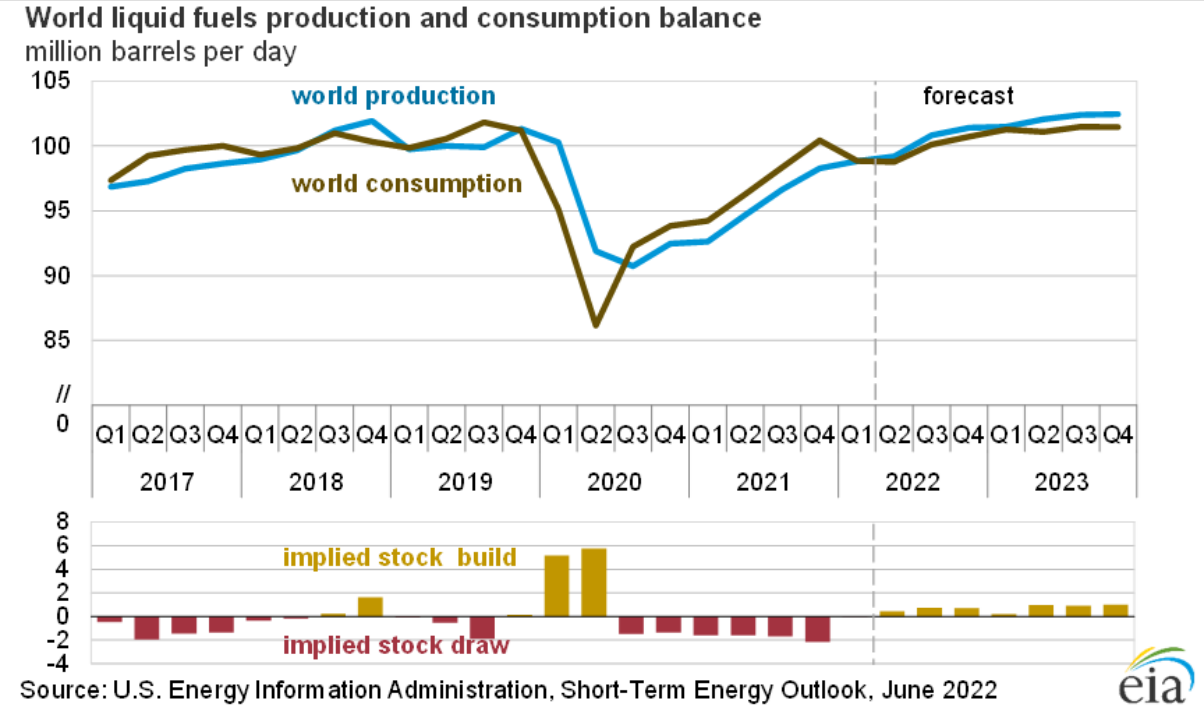
ARIES DOCTORAL TRAINING PARTNERSHIP
Oil Spill Response

Background - Why is this important?



- Steady increase from 73 to 100 million barrels per day since 2010
- Estimated to reach 101 million barrels per day by the end of 2022
- 35% rise in volume of oil from 2.5 to 3.3 billion barrels per year in need of transport

(Rystad Energy, 2022; U.S. Energy Information Administration, 2022)

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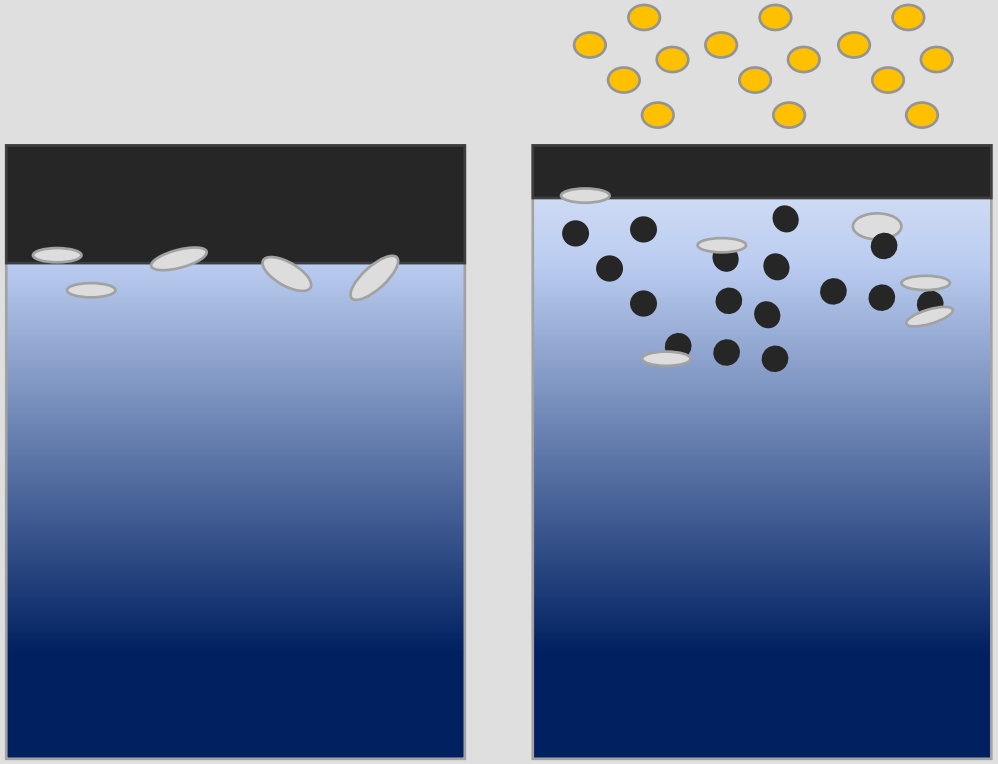

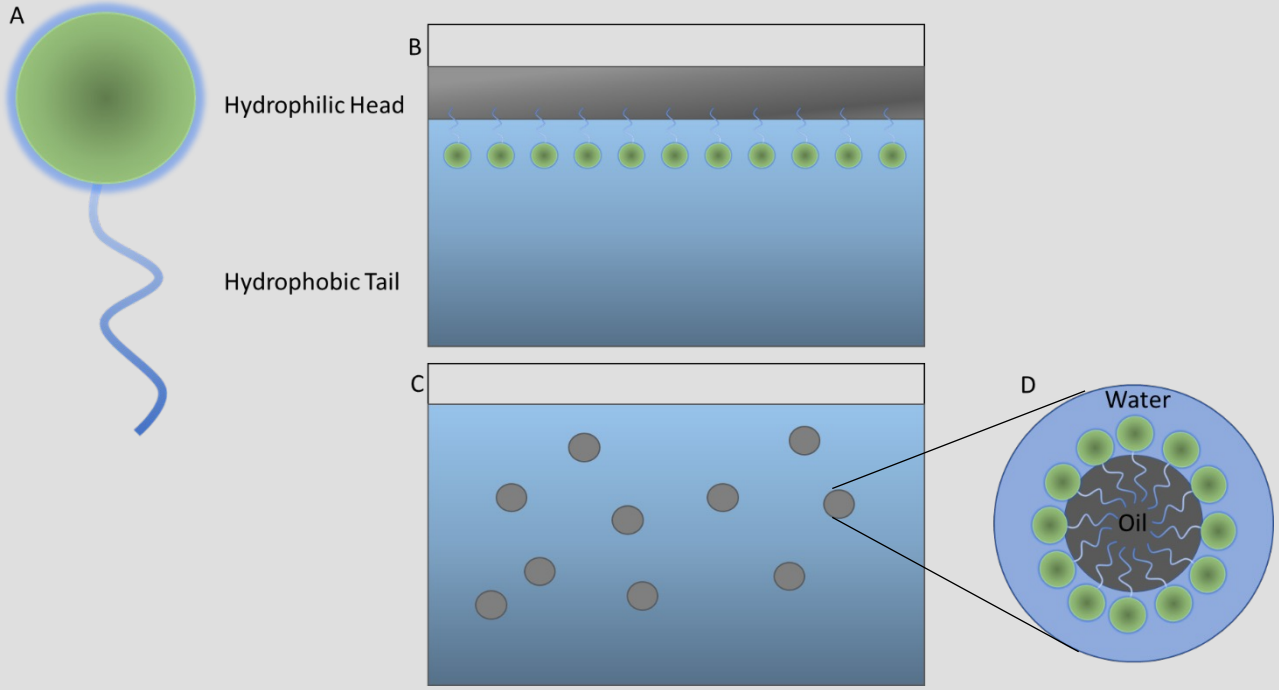

(Dave and Ghaly, 2011; Prince et al., 2013; Kleindienst et al., 2015a; Kleindienst et al., 2015b; 2016; Techtmann et al., 2017; Trembley et al., 2017; Thomas et al., 2021)

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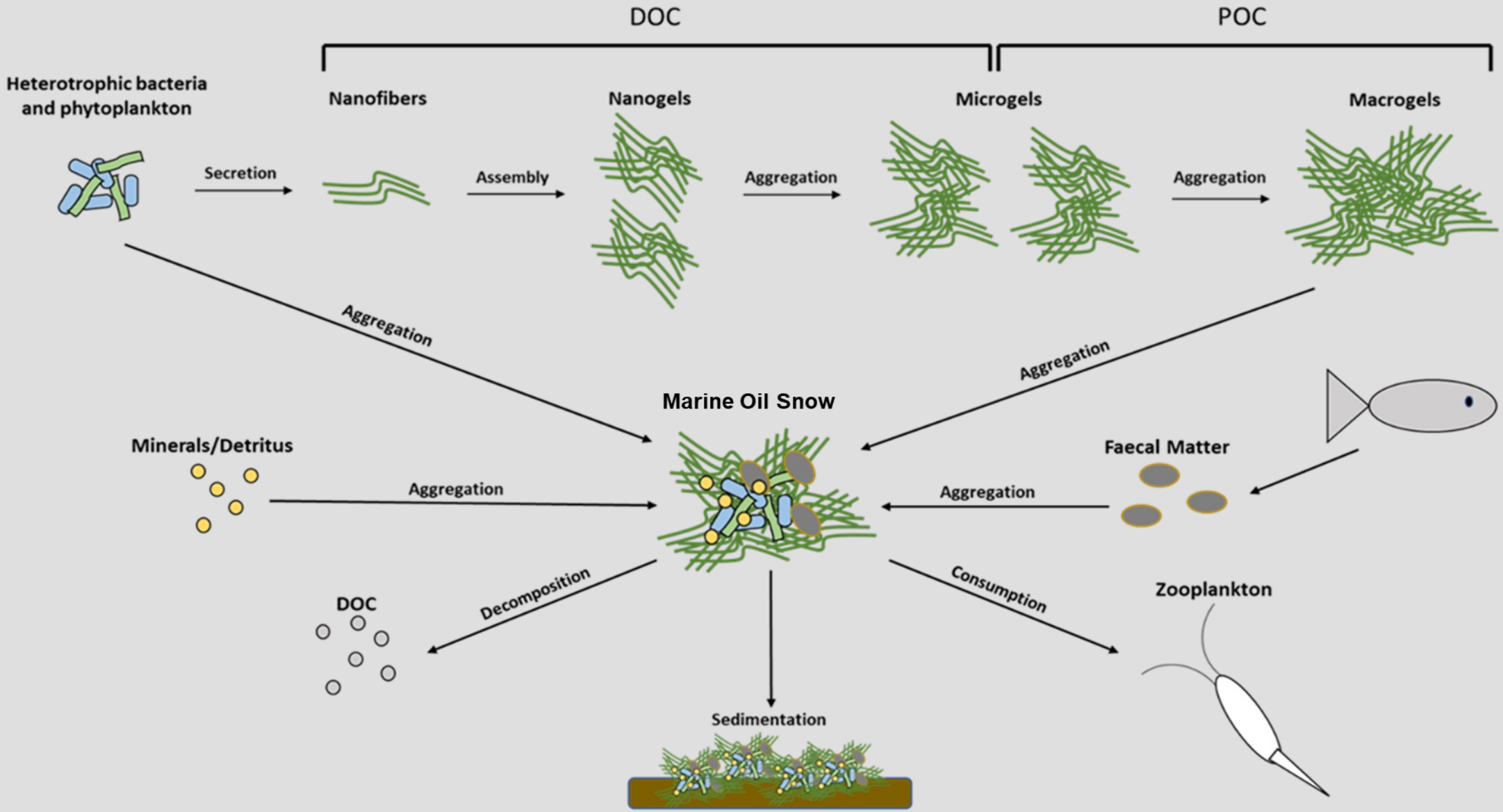

(Passow *et al*., 2012; Bochdansky *et al*., 2017; Burd et al., 2020; Gregson et al., 2021

Background - Why is this important?

frontiers in Marine Science

REVIEW
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Marine Oil Snow, a Microbial Perspective

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Under certain conditions, dispersed crude oil in the sea combines with organisms, organic matter, and minerals to form marine oil snow (MOS), thereby contributing to the sinking of oil to the seafloor. Marine microbes are the main players in MOS formation, particularly via the production of extracellular polymeric substances. Distinct groups of microbes also consume the majority of the hydrocarbons during descent, leading to enrichment of the less bioavailable hydrocarbons and asphaltenes in the residue. Here we discuss the dynamics of microbial communities in MOS together with their impacts on MOS evolution. We explore the effects of dispersant application on MOS formation, and consider ways in which laboratory experiments investigating MOS formation can be more representative of the situation in the marine environment, which in turn will improve our understanding of the contribution of MOS to the fate of spilled oil.

Keywords: marine oil snow, marine snow, hydrocarbon biodegradation, hydrocarbonoclastic bacteria, extracellular polymeric substances, oil-spill response

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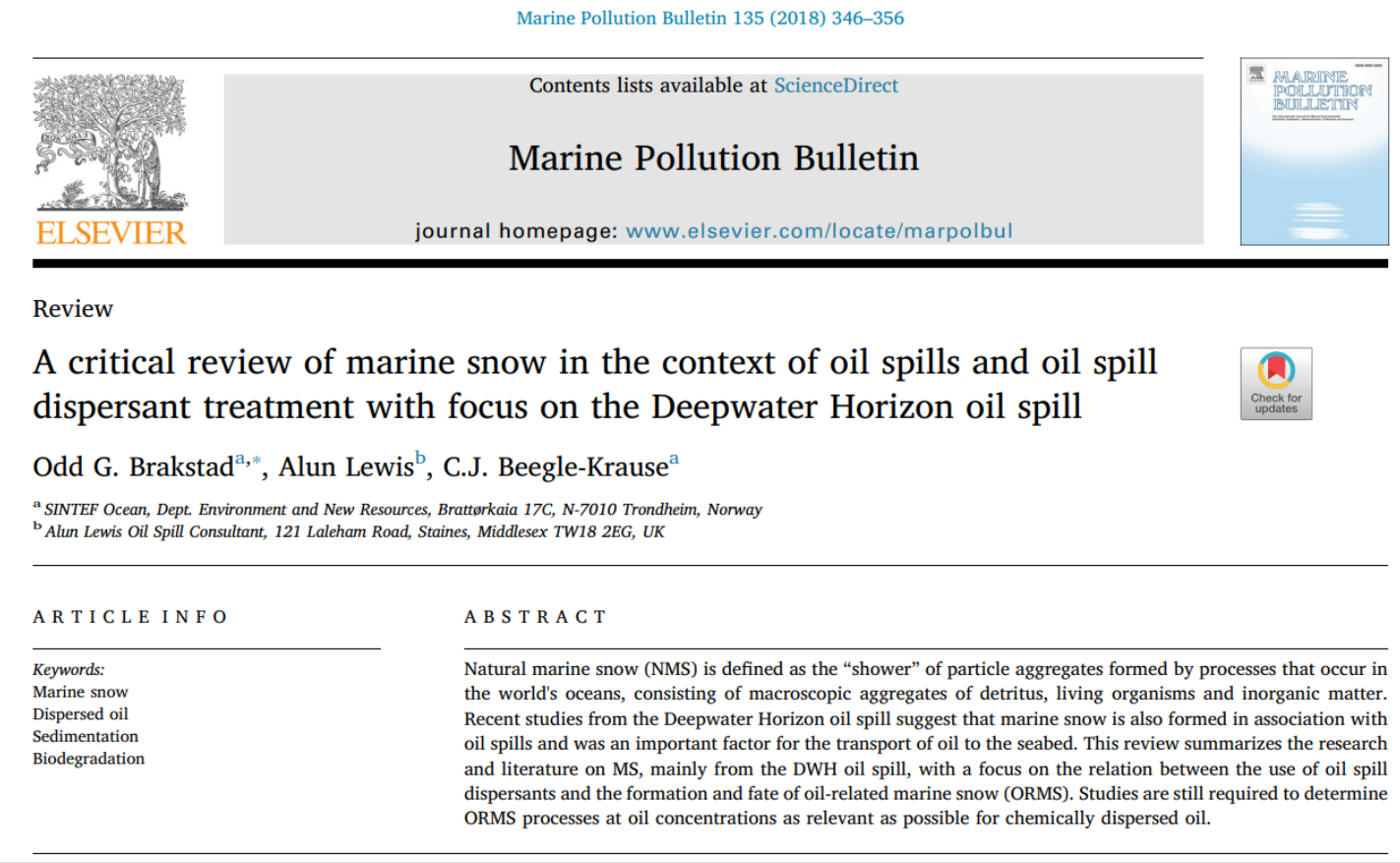

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Review

A critical review of marine snow in the context of oil spills and oil spill dispersant treatment with focus on the Deepwater Horizon oil spill

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ABSTRACT

Natural marine snow (NMS) is defined as the "shower" of particle aggregates formed by processes that occur in the world's oceans, consisting of macroscopic aggregates of detritus, living organisms and inorganic matter. Recent studies from the Deepwater Horizon oil spill suggest that marine snow is also formed in association with oil spills and was an important factor for the transport of oil to the seabed. This review summarizes the research and literature on MS, mainly from the DWH oil spill, with a focus on the relation between the use of oil spill dispersants and the formation and fate of oil-related marine snow (ORMS). Studies are still required to determine ORMS processes at oil concentrations as relevant as possible for chemically dispersed oil.

Highlights:

- Marine snow aggregates may form in association with oil spills.
- The DWH oil spill was the first spill with attention to oil-related marine snow.
- The use of oil spill dispersants was suggested to cause oil-related marine snow.
- Formation of oil-related marine snow was suggested to cause oil sedimentation
- Studies are still required to determine marine snow processes at low oil concentrations.

Background - Why is this important?

ENVIRONMENTAL Science & Technology

Article

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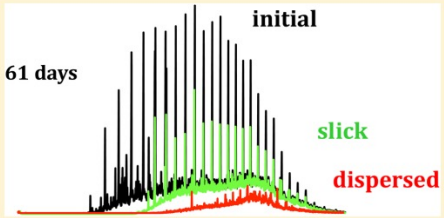
The Rate of Crude Oil Biodegradation in the Sea

Roger C. Prince,* Josh D. Butler, and Aaron D. Redman

ExxonMobil Biomedical Sciences, Inc. Annandale, New Jersey 08801, United States

Supporting Information

ABSTRACT: Various groups have studied the rate of oil biodegradation in the sea over many years, but with no consensus on results. This can be attributed to many factors, but we show here that the principal confounding influence is the concentration of oil used in different experiments. Because of dilution, measured concentrations of dispersed oil in the sea are sub-parts-per-million within a day of dispersal, and at such concentrations the rate of biodegradation of detectable oil hydrocarbons has an apparent half-life of 7−14 days. This can be contrasted with the rate of degradation at the higher concentrations found in oil slicks or when stranded on a shoreline; there the apparent half-life varies from many months to many years.



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Lab tests on the biodegradation of chemically dispersed oil should consider the rapid dilution that occurs at sea ☆

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[b] CSIRO, Australian Resources Research Centre, Kensington, Western Australia 6151, Australia
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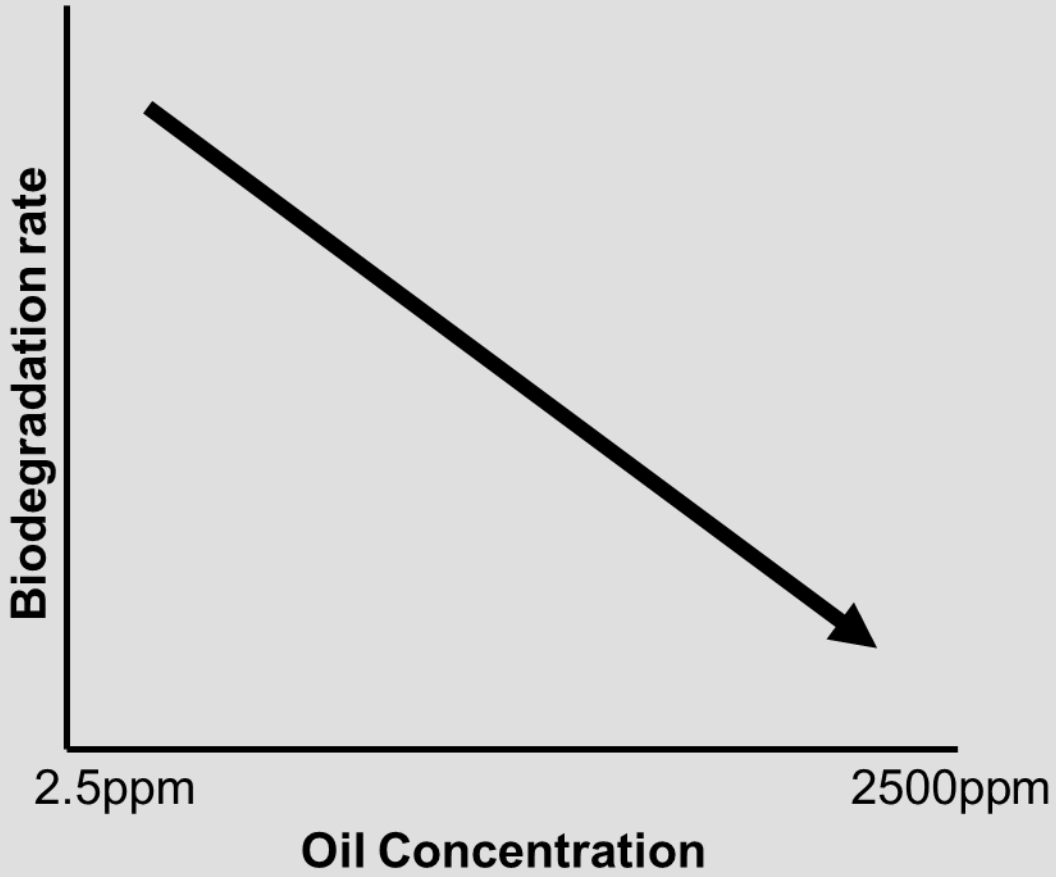
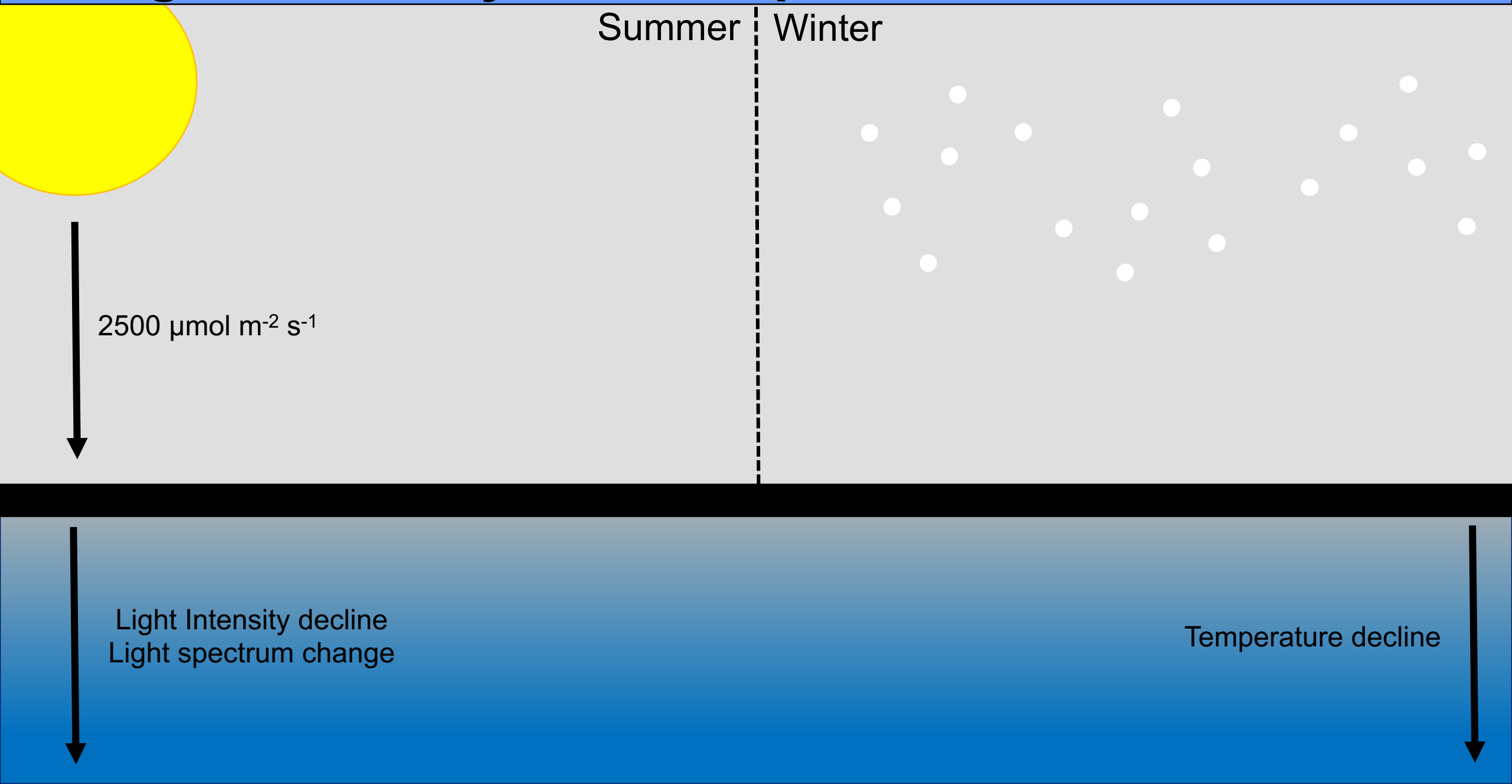
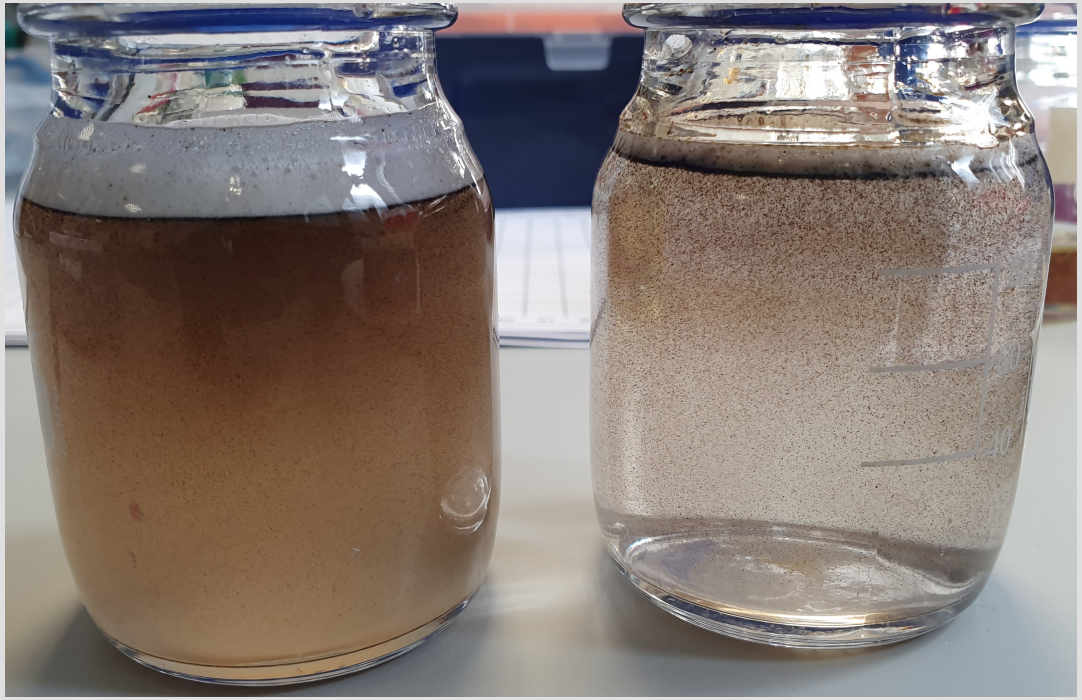


(Lee et al., 2013; Kleindienst *et al.*, 2015b; Prince et al., 2017; McFarlin and Prince, 2021)

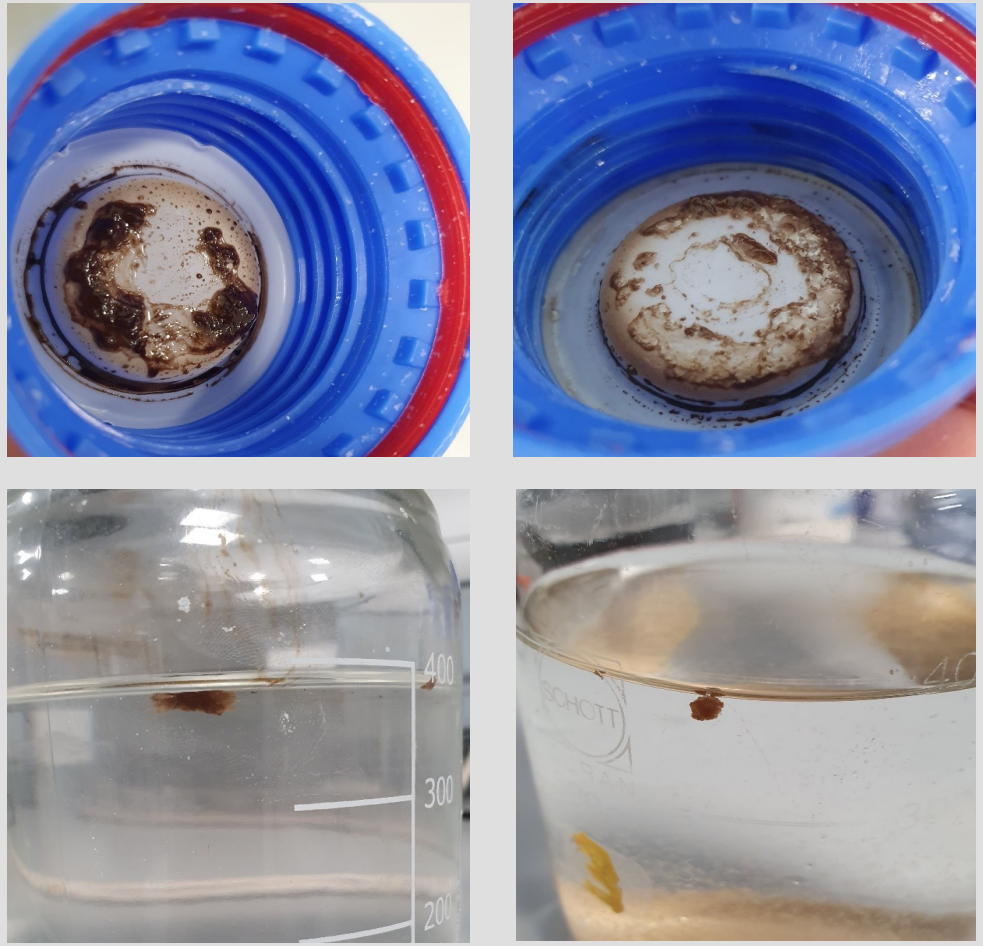
Background - Why is this important?



Current Research



Chemical Dispersant effectiveness
and impact in a marine environment



Marine Oil Snow Formation

Experimental Design

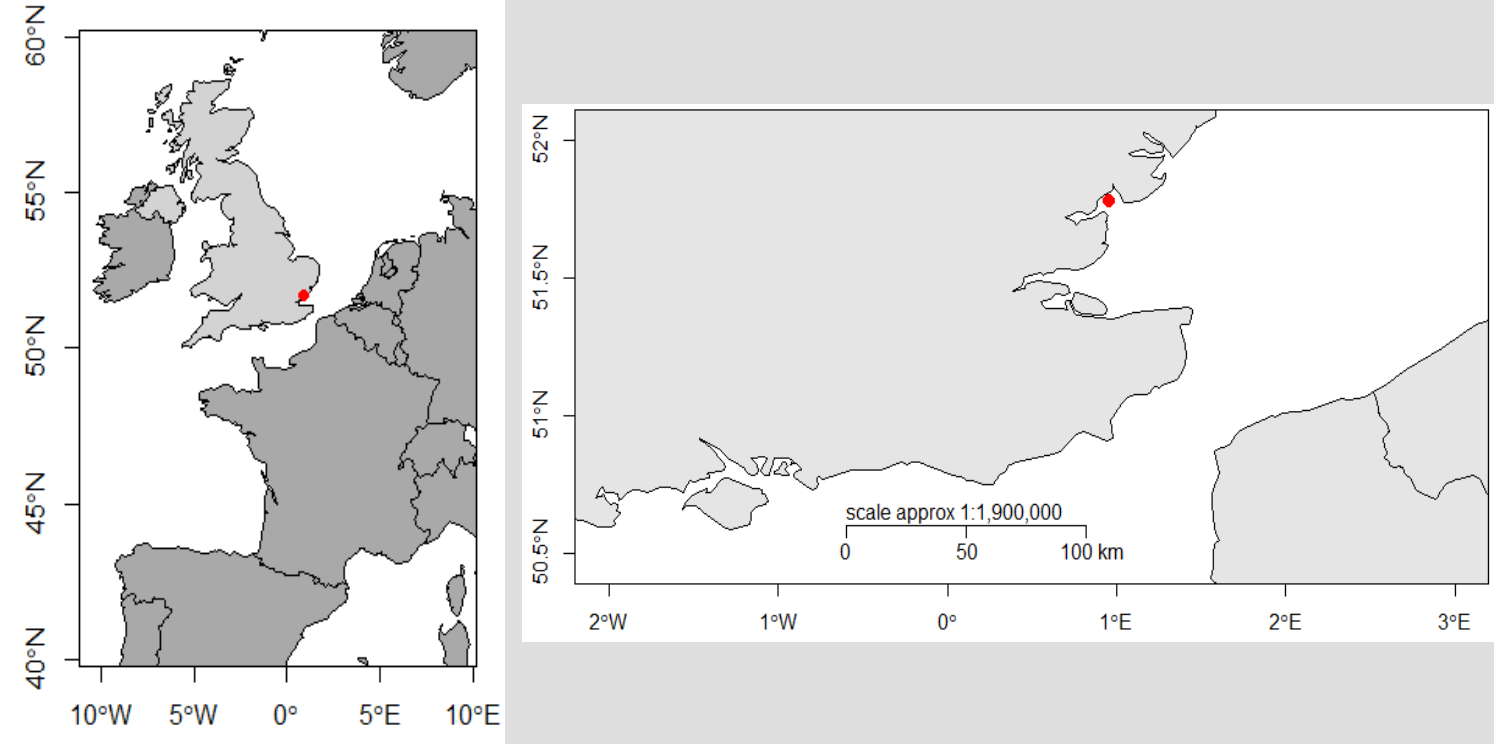


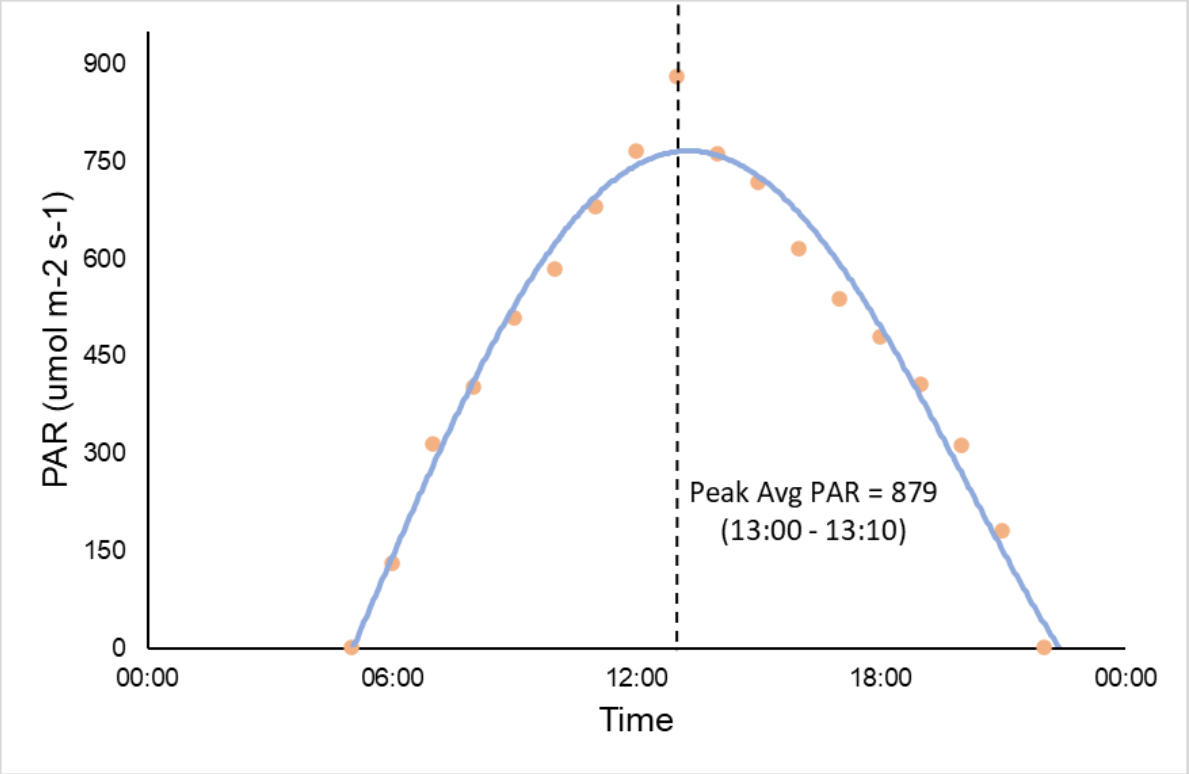
Figure 1: Map of sample site (Red dot): Mersea Island, Essex, Southeast United Kingdom

- 18 Treatments (Triplicate) – 40ml glass vials
- Time points (Days) – 0, 1, 3, 6 and 14
- Seawater sample – 20ml
- Oil concentrations:
  - 1000ppm
  - 100ppm
  - 10ppm
  - 1ppm
- Chemical Dispersant – Slickgone NS at a ratio of 20:1 (Oil:Dispersant)

Analysis:

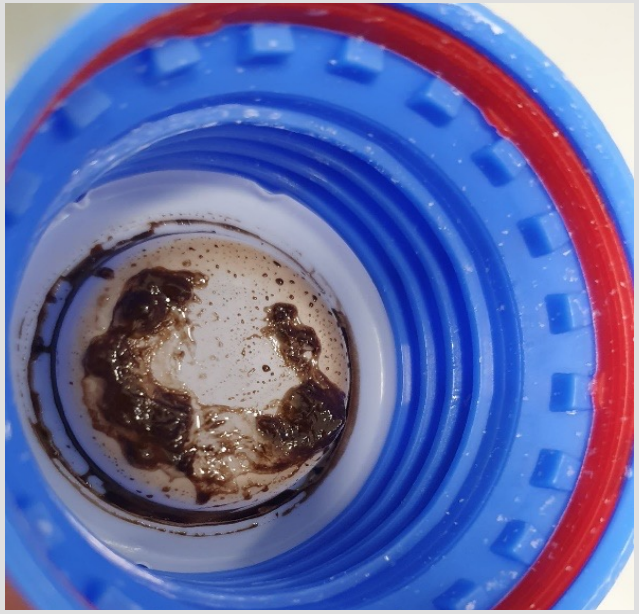
- Hydrocarbon degradation
- Nutrient Analysis
- Microbial growth/community composition

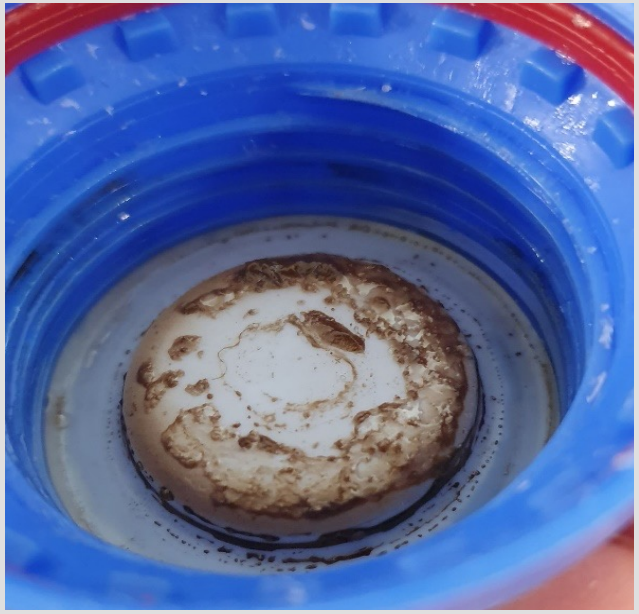
Experimental Design

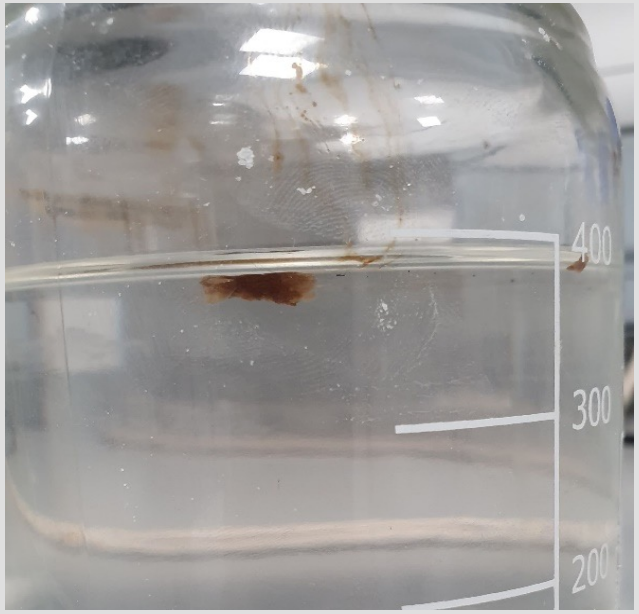


- 400ml Seawater sample – North Sea
- Oil concentrations:
  - 100ppm (0.1%) – 40ul
- Chemical Dispersant – Corexit 9500 at a ratio of 20:1 (Oil:Dispersant)

Experimental Design







What is next?

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Thank you for listening

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