Fisheries and Oceans Canada | Pêches et Océans Canada

Ecosystems and Oceans Science | Sciences des écosystèmes et des océans

Canadian Science Advisory Secretariat (CSAS)

Proceedings Series 2023/010

National Capital Region

Proceedings of the National Advisory Meeting on the State of Knowledge on Chemical Dispersants for Canadian Marine Oil Spills

March 1–12, 2021
Virtual Meeting

Chairpersons: James McCourt and Lisa Setterington
Editors: Ryan Greig, Lisa Isaacman, Kenneth Lee, Shannon Stuyt, and Alex Tuen

Fisheries and Oceans Canada
200 Kent Street
Ottawa, ON K1A 0E6

April 2023

Canada

Foreword

The purpose of these Proceedings is to document the activities and key discussions of the meeting. The Proceedings may include research recommendations, uncertainties, and the rationale for decisions made during the meeting. Proceedings may also document when data, analyses or interpretations were reviewed and rejected on scientific grounds, including the reason(s) for rejection. As such, interpretations and opinions presented in this report individually may be factually incorrect or misleading, but are included to record as faithfully as possible what was considered at the meeting. No statements are to be taken as reflecting the conclusions of the meeting unless they are clearly identified as such. Moreover, further review may result in a change of conclusions where additional information was identified as relevant to the topics being considered, but not available in the timeframe of the meeting. In the rare case when there are formal dissenting views, these are also archived as Annexes to the Proceedings.

Published by:

Fisheries and Oceans Canada
Canadian Science Advisory Secretariat
200 Kent Street
Ottawa ON K1A 0E6

http://www.dfo-mpo.gc.ca/csas-sccs/
csas-sccs@dfo-mpo.gc.ca

ISSN 1701-1280
ISBN 978-0-660-48338-2 Cat. No. Fs70-4/2023-010E-PDF

Correct citation for this publication:

DFO. 2023. Proceedings of the National Advisory Meeting on the State of Knowledge on Chemical Dispersants for Canadian Marine Oil Spills; March 1–12, 2021. DFO Can. Sci. Advis. Sec. Proceed. Ser. 2023/010.

Aussi disponible en français :

MPO. 2023. Compte rendu de la réunion sur les avis scientifiques national sur l’état des connaissances sur les dispersants chimiques pour les déversements d’hydrocarbures en mer au Canada; du 1er au 12 mars 2021. Secr. can. des avis sci. du MPO. Compte rendu 2023/010.

TABLE OF CONTENTS

SUMMARY

Canada has a strong marine safety system; however, the Government of Canada has recently dedicated significant resources to further enhance specific aspects of this environmental protection and emergency response regime.

When there is an oil spill in the marine environment, Fisheries and Oceans Canada and the Canadian Coast Guard use science-based advice to inform decisions that facilitate cleanup and protect aquatic resources and ecosystems from negative impacts. To support decision-making, there is a need to understand the effectiveness of all available response tools (including chemical oil dispersants) that could reduce the potential for adverse effects on marine ecosystems.

A formal, science advisory process on the topic of dispersant use in Canada was held in March, 2021. A group of international, technical experts from government, industry and academia came together (virtually), to contribute their knowledge, experience, perspectives and research outcomes towards the development of the science advice. This Proceedings Document is the record of meeting discussions, recommendations, and conclusions.

INTRODUCTION

When there is an oil spill in the marine environment, Fisheries and Oceans Canada (DFO) and the Canadian Coast Guard (CCG) use science-based advice to inform decisions that facilitate cleanup and protect aquatic resources and ecosystems from negative impacts. Following an oil spill, there is a need to assess and evaluate the effectiveness of all available response tools that could reduce the potential for adverse effects on marine ecosystems, including the consideration of spill treating agents such as chemical oil dispersants.

Since the Deepwater Horizon (DWH) spill in the Gulf of Mexico in 2010, there has been extensive research and scientific advancement related to dispersant use. This recent scientific information, available through various fora, has not yet been critically evaluated specific to its applicability within a Canadian context. The advice generated from this meeting will be used to:

- Efficiently inform critical and time sensitive spill response decisions (such as net environmental benefit determinations);
- Provide consensus-based, scientific advice to inform and support the communication of spill response decisions;
- Support and inform the development of regulations, policies, standards and guidance for dispersant use; and,
- Support various other Government of Canada initiatives related to spill response.

On March 1–12, 2021, a virtual National Advisory Meeting was held to consolidate, assess, and critically evaluate the current state of knowledge on dispersants as it applies to a Canadian context. This meeting addressed the following questions in the Terms of Reference, found in Appendix 1 of this Proceedings Document.

1. How does applying dispersants change the movement of oil and exposure to sensitive receptors (e.g., aquatic species, habitats, and other sensitive coastal or marine areas)?
2. What are the differences in exposure and effects between untreated oil and dispersed oil and their potential short- and long-term impacts on sensitive receptors?
3. What are the key considerations or recommendations for environmental monitoring after dispersant use?
4. What are the priority, outstanding science needs to support the regulatory regime and decision-making for the use of dispersants in Canada?

This Proceedings Document is the record of meeting discussions, recommendations, and conclusions. The Terms of Reference questions were addressed, forming the basis of the Summary Bullets for the Science Advisory Report. A draft Working Paper was discussed, and formed the basis for the Research Document. These publications will be posted on the [Fisheries and Oceans Canada (DFO) Science Advisory Schedule] as they become available.

PRESENTATIONS: ABSTRACTS AND DISCUSSIONS

The virtual meeting series was structured around the Terms of Reference questions (Appendix 1). The first five meetings had brief presentations, followed by discussions and initial drafting of the science advice. The sixth meeting focused on the refinement of the science advice (see Appendix 2 for the meeting agenda).

These Proceedings are structured to reflect the presentations and resulting discussions, followed by the summary of discussions that informed the development of the science advice.

OVERVIEW OF THE CANADIAN RESPONSE REGIME

Presenter: Boumy Sayavong

Abstract

The Canadian Coast Guard (CCG) presented an overview of the Canadian response regime. The overview recognized the roles of different agencies based on the pollution source and the common structural pillars across all regimes (i.e., prevention, preparedness and response, liability, and compensation). The presentation discussed the use of the Incident Command System in support of response operations and described the response measures currently available for ship-source oil pollution incidents in Canadian waters. Last, it emphasized the polluter pay model upon which the Canadian system is founded.

Discussion

CCG's responsibility is to ensure that the information generated from this meeting will help decision-making in the future.

FOUNDATIONAL DISPERSANT SCIENCE

Presenter: David Creber

Abstract

Dillon Consulting Limited (Dillon) presented a summary from their Working Paper, specifically focused on foundational dispersant science. The presentation summarized the history of dispersant use, an overview of dispersant composition, how they function and the types of oil for which dispersants are effective. The presentation also summarized key environmental factors (including Arctic and cold water conditions) that may limit the window of opportunity for dispersant use. In addition, the presentation discussed the current regulatory framework for dispersant use in Canada, the net environmental benefit analysis framework to support decision-making, as well as the advantages and challenges associated with dispersants as a response tool.

Discussion

Participants proposed the following revisions and refinements to the Working Paper:

- Include a discussion on the limits of salinity. For example, while not effective in distilled water, dispersants may still be effective at salinity levels of twenty parts per thousand or lower.
- Include a reference to the International Tanker Owners Pollution Federation (ITOPF) 2014 Technical Information Paper on Dispersants in the references section of the Working Paper.
- Acknowledge that not all oil in the environment will be diluted. For example, the formation of marine oil snow results in oil becoming concentrated and falling to the sea floor without becoming diluted.
- Change the reference from "Canada Oil and Gas Corporations Act" to "Canada Oil and Gas Operations Act".

- Change the definition of surfactants to reflect that they "lower interfacial tension" rather than "lowering surface tension".
- Replace Table 2's term "dispersibility" with "efficacy of dispersant application".
- There were discussions as to whether both Corexit 9500 and 9580 should be reflected in the Working Paper. Both are approved for use in Canada for offshore oil and gas activities; however, 9580 is a cleaning agent and is not approved as a dispersant. Subsequently, participants agreed that Corexit 9500 should be listed as the sole dispersant approved in Canada. It will be clarified in the Working Paper that while two spill treating agents are regulated, only one is used as a dispersant.
- Acknowledge in the Working Paper that there are many situations where dispersants are effective in a low sea state, as well as sea states that will naturally break up any surface oil, without the need for dispersants.
- Dispersant effectiveness will depend on various factors, including the type of oil, type of dispersant, and application technique. The application of dispersants is based on the consideration of multiple variables.

Worker health and safety regarding the implications and use of dispersants was acknowledged as a consideration but was outside the scope of this advice.

REVIEW AND INSIGHTS FROM INDUSTRY-LED RESEARCH: EXXONMOBIL

Presenter: Tim Nedwed

Abstract

ExxonMobil presented a review and insights from industry-led research. The presentation focused on a review of existing response tools, their purpose, advantages, and limitations. It emphasized the need for access to complimentary response tools which can offer rapid deployment and higher encounter rates for large, complex and/or subsea oil spills. It also discussed some of the challenges of translating lab-based oil spill fate and effects studies into estimated real-world impacts.

Discussion

No questions arose and no discussion ensued.

REVIEW AND INSIGHTS FROM INDUSTRY-LED RESEARCH: AMERICAN PETROLEUM INSTITUTE PROJECTS AND TECHNOLOGY

Presenter: Victoria Broje

Abstract

The American Petroleum Institute (API) presented a review and insights from their science and technology working group as well as the current state of knowledge on dispersants. The presentation summarized some of the education and outreach activities completed by API, as well as their operational guides for dispersant use and monitoring. The presentation summarized the current state of knowledge specific to:

- The effectiveness of subsea dispersant injection (SSDI);
- Dispersed oil fate;

- Effects from dispersed oil;
- Decision-making frameworks (such as Comparative Risk Assessment); and,
- Impacts from surface slicks on air quality.

Last, it presented a summary of key, ongoing, and international dispersant research initiatives.

Discussion

No questions arose and no discussion ensued.

REVIEW AND INSIGHTS FROM DEEPWATER HORIZON / GULF OF MEXICO RESEARCH INITIATIVE (GOMRI)

Presenter: Gina Coelho

Abstract

The Bureau of Safety and Environmental Enforcement presented a review and insights from after action and monitoring reports from the Deepwater Horizon (DWH) spill, as well as key outcomes from the Gulf of Mexico Research Initiative (GoMRI). The presentation included an overview of the DWH spill, the aerial and subsea dispersant application tactics, as well as the monitoring activities that took place. It also summarized future planning and research initiatives related to: dispersant operations and monitoring.

Discussion

No questions arose and no discussion ensued.

FATE AND BEHAVIOUR

Presenter: David Creber

Abstract

Dillon presented a summary from their Working Paper, specifically focused on fate and behaviour. The presentation provided a comprehensive overview of oil weathering and transport processes, then discussed how they are influenced/affected through the application of dispersants. It also summarized the processes by which marine oiled snow is formed and highlighted key considerations for subsea dispersant use. Last, the presentation emphasized the key considerations for fate and transport, specifically related to Arctic and cold water conditions.

Discussion

The Environment Canada Crude Oil and Petroleum Product Database was shared with the participants. It has been online since 2017 and updated as recently as January 2021.

Regarding biodegradation of oil, the following points were raised:

- It cannot be stated with certainty that dispersants increase photodegradation because the oil is moved into the water column, where light penetration can vary.
- Dispersants increase dissolution rate.

- Dispersants biodegrade. For example, the surfactants in Corexit 9500 are derived from natural esters and sorbitols, which naturally degrade in the environment. In addition, some detergents (such as Triton X-100) are also shown to be biodegradable based on their composition.
- The mode of action for dispersants is not based on nutrient enrichment. Thus, the mention of dispersants acting as a food source in the Working Paper should be clarified.
- Dispersants do not necessarily increase marine oil snow. In some research (Passow pers comm.) less marine oil snow was found when dispersants were used because organisms produced less mucus. It was discussed that there are multiple, interacting processes and it can be difficult to predict which process will dominate. It was noted that it is important to acknowledge that marine oil snow tends to occur in locations with robust biodegradation.
- It is necessary to work with concentrations of oil that are more representative of what might realistically be observed in the environment. Close to an oil slick, microbes are exposed to high concentrations of oils and will adhere to oil drops in excess of one to two parts per million. The chairs clarified that this specific topic would be better addressed during upcoming discussions on toxicity and direct impacts of oil on species and organisms.

Additional considerations for the Working Paper include photodegradation, phototoxicity, photooxidation, and the influence of turbidity.

There was a discussion on the topic of fate and transport models. The following points were raised:

- It is important to distinguish between fate, behaviour and transport models (e.g., OilMap) versus models that also consider biological effects (e.g., SIMAP), which serve two different purposes.
- Oceanographic circulation and hydrodynamic models are important inputs. Such models exist for specific areas in Canada but are not nationally available.
- For oil dispersion and oil distribution, key considerations include inflow, outflow, and the scale of models used by oceanographers.
- Including confidence intervals and/or communicating uncertainties within the models is particularly important, especially in the context of incident response, when models may need to be generated quickly to meet operational needs. A paper on the subject by Manning et al. (2021) was shared with participants.

REVIEW AND INSIGHTS FROM THE CENTRE FOR OFFSHORE OIL, GAS, AND ENERGY RESEARCH'S (COOGER) RESEARCH

Presenter: Tom King

Abstract

DFO presented research insights from the Centre for Offshore Oil, Gas, and Energy Research (COOGER). The presentation summarized some of the factors affecting oil dispersant effectiveness, and departmental research on the influence of dispersants on oil droplet size distribution and weathering processes. It also summarized the current Departmental research on microbial interactions and biodegradation rates.

Discussion

No questions arose and no discussions ensued.

REVIEW AND INSIGHTS FROM ACADEMIC RESEARCH

Presenter: Michel Boufadel

Abstract

The New Jersey Institute of Technology presented a review and insights from academic research. The presentation focused on the current state of knowledge and modelled predictions specific to oil droplet size distribution. It also emphasized the presence of natural energy sources (e.g., eddies and currents) below the water/ice surface and the relevance for dispersant use and oil droplet distribution.

Discussion

When oil is dispersed from the water surface, a plume is typically generated within the top ten metres of the water column. This plume could persist but will generally diffuse downward due to the nature of turbulence. Because the ocean is more than a column, the oil is expected to diffuse from an area of high concentration (typically at the surface) to an area of low concentration (typically at depth). The buoyancy of the oil droplets is a key factor that can impact diffusion. Overall, the more diffusion and more dispersion, the lower the concentrations in the environment. It was recommended that the influence of diffusion be emphasized in the Working Paper.

In the context of the presentation, it was clarified that the mixing layer was defined as depths of 20 to 140 metres; however, there is no abrupt or consistently defined boundary in the environment. It was acknowledged that dispersed oil could continue to diffuse below the mixing layer but this would be defined by the diffusion coefficient and the level of turbulent diffusion.

The Working Paper document recommends that dispersants should not be used in waters ten metres or shallower. Typically, water needs to be deeper before applying dispersants. However, sometimes the need arises to apply dispersants in shallow (ten metres or less) waters; for example, mangroves and sensitive environments on the shoreline.

In the United States in the mid-1990s, preauthorization guidelines were established, and the rule for dispersant application was not always three nautical miles offshore. The process at the time was not based on modelling, but on empirical data. In a coastal area, with wind activity, the area will be mixed within hours, because horizontal dilution is faster than vertical dilution.

There was no objective science that decided on the guidelines for dispersant use in water depths greater than ten metres and three or more nautical miles offshore. These figures were conservative and intuitive, appearing in publications and contingency plans as general guidelines in the 1990s.

HOW THE APPLICATION OF DISPERSANTS CAN ALTER THE PATHWAYS FOR EXPOSURE

Presenter: Rob Willis

Abstract

Dillon presented a summary from their Working Paper, specifically focused on pathways of exposure for organisms and habitats. The presentation centered around the topics of pathways of effects, biological components of concern, and exposure pathways, as well as the associated interactions. The presentation then summarized how the use of dispersants could affect each of these and the key considerations to help inform decision-making.

Discussion

The published chemical composition of Corexit 9500 was shared with the participants.

A distinction needs to be made between a “dispersant product” and a “type of dispersant”. For example, Corexit 9500 is a specific product whereas biodispersants would be a type.

Dispersants reduce oil droplets in size, from the millimeter magnitude to the nanometer magnitude.

The rate at which subsea dispersed oil rises is dependent on the buoyancy of the oil droplets. Smaller droplets are less buoyant and rise slower through the water column.

When discussing trade-offs (in the context of exposure), there needs to be a timely consideration of contextual realities. Under conditions of high winds or sea state (waves) it is likely that there will be natural dispersion, without the need for augmentation from dispersants. The outcome (whether naturally- or chemically-dispersed) will be similar with respect to exposure.

Consideration must also be given to the difference in the duration of exposure (and the resulting effects) between naturally- or chemically-dispersed oil and undispersed oil. Also oil that reaches shorelines will persist and result in prolonged exposure for sensitive species, habitats and ecosystems.

Because the oil properties change over time, the distinction between “oil” and “residual oil” should be specified in the Working Paper. In the context of oil for sedimentation, it should refer to residual oil, which has been weathered.

Other considerations include net environmental benefit analysis (NEBA), the impacts on species, and the time factor for approval of use, which is particularly important to operations. While timelines for approval decisions are critically important considerations, the topic was outside the scope of this process.

REVIEW AND INSIGHTS FROM THE UNITED STATES NATURAL RESOURCE DAMAGE ASSESSMENT (NRDA) EXPERIENCE

Presenter: Douglas Helton

Abstract

The National Oceanic and Atmospheric Administration (NOAA) presented the Natural Resource Damage Assessment (NRDA) process in the United States and its considerations for ecosystem exposure pathways. The presentation started with an overview of the approach to dispersant use in American Arctic waters, followed by an overview of the NRDA process (generally). It then summarized the outcomes from the detailed NRDA for the DWH spill and provided some context about dispersant use for other spills in the United States.

Discussion

There were discussions about the mechanisms by which dispersed oil from the DWH spill reached shorelines. Oil that remains on the surface can be transported to the shoreline through wind. Oil that is dispersed into the water column will be transported by currents, which travel parallel to the shore. In addition, when oil is effectively dispersed at the surface, within hours, concentrations in the water column are significantly reduced. During the DWH spill, the conditions in the gulf provided a transport mechanism for chemically-dispersed oil to reach shorelines if the oil droplets were not fully dispersed into the water column. Trace amounts of dioctyl sodium sulfosuccinate (DOSS), the main active component of Corexit, were detected on some shorelines; however, it was noted that concentrations were very low and there are other contributing sources of DOSS in those same areas.

The "*Provenance of Corexit-related chemical constituents found in nearshore and inland Gulf Coast waters*" paper was shared with the participants, which described the presence of identical components present within Corexit being found nearshore with a conclusion that they were likely associated with urban runoff.

At present in Canada, the use of dispersants is limited to offshore platforms on the east coast. These platforms operate at depth, where generally, the underwater currents would be more likely to carry oil out to sea (where it would be dispersed), rather than towards shore.

There were discussions on the subject of subsea trajectory models and their ability to accurately predict the movement of oil droplets over space and time. It was acknowledged that predictions are estimates, based on the best available information at the time, and results from hind cast models or with the benefit of hindsight can differ. While models continue to be refined based on new information, research, and empirical evidence, current models are effective at providing an estimate of subsea oil droplet movement.

There were discussions about the potential for chemically-dispersed oil to resurface and recoalesce. The general consensus was that chemically-dispersed oil is unlikely to recoalesce. It was also acknowledged that the rate of dispersion in ocean systems is significant. Throughout the DWH spill, thousands of samples were collected, but very few were found to have oil concentrations above one part per million (ppm).

It was acknowledged that while the focus of dispersant discussions tends to be on physical toxicity, consideration should also be given to mechanical interactions. For example, recent studies have shown that dispersants impact birds' feathers, feather function, feather structure, thermal regulation, and waterproofing.

Dispersants have not been used in the United States since the DWH spill for numerous reasons, including:

- A decline in larger, more significant spills that may warrant their use;
- Increased spill prevention efforts from Industry; and,
- Political concerns.

The use of dispersants has been assessed for some spills since DWH; however, the specific circumstances of the spill (e.g., projected oil trajectories towards sensitive resources) and the associated trade-off analysis did not favour their use. As was previously discussed, mechanical recovery will always be the preferred response method. Dispersants are an additional response tool when other mechanisms are insufficient.

The following were discussed in the context of contingency planning for dispersant use in Alaska, which may be factors or considerations for a Canadian regime:

- Ecological sensitivities;
- Protection priorities, informed through consultation with Indigenous groups, resource managers and industry;

- Logistics and mobilization times; and,
- Windows of opportunity for dispersant use.

Alaska undertook a comprehensive analysis of different response tools (e.g., mechanical recovery, burning, and dispersants), including an analysis of the windows of operational feasibility. This analysis concluded that the operational constraints of sea state, wind, daylight hours, etc. meant that dispersant use would only be appropriate approximately one-third of the time.

An overview of the offshore response to the 1996 Sea Empress spill in the UK was shared with the participants and describes the use of mechanical recovery and dispersants.

WHAT ARE THE DIFFERENCES IN AND EFFECTS BETWEEN UNTREATED OIL AND DISPERSED OIL?

Presenter: Rob Willis

Abstract

Dillon presented a summary from their Working Paper, specifically focused on effects and impacts. The presentation distinguished key terms, provided a broad overview of effects and impacts from both oil and dispersed oil, outlined key challenges regarding dispersant toxicity studies, and emphasized the value of modelling.

Discussion

Chemical toxicity is a complex topic that is difficult to generalize across products, species, and scientific methods.

It was noted that in the context of toxicity studies, only the first hours or days tend to be considered, but an evaluation of exposure, dose, and impacts over the lifetime of a spill should be assessed. The example presented was the potential exposure of an organism over the entire duration of a spill. If dispersants are not applied, an organism may be directly or indirectly exposed to a larger surface slick over a prolonged period of time and could be exposed to oil over the long-term if it reaches a shoreline. In comparison, if the oil were dispersed, the same organism may be differentially exposed to the oil (at the surface and in the water column) but for a shorter period of time. Only when the entire context of the spill is considered can the trade-off between the use and non-use of dispersants be appropriately compared.

Discussion ensued regarding chemically- versus physically-dispersed oil composition and toxicity. An article on "*The acute toxicity of chemically and physically dispersed crude oil to key arctic species under arctic conditions during the open water season*" was shared with the participants.

Discussion took place regarding the specific concentrations referenced in the presentation and used to compare the toxicity of untreated oil versus dispersed oil. This was followed by a discussion regarding the different, standardized methods for toxicity tests and the differences between variable dilution and variable loading. Overall, the outcomes of the discussions suggested that data from laboratory studies are more useful in informing models than predicting what will happen in the real world.

REVIEW AND INSIGHTS RELATED TO DISPERSED OIL TOXICITY

Presenter: Benjamin de Jourdan

Abstract

Huntsman Marine Science Centre presented a review and insights related to dispersed oil toxicity based on their current research. The presentation provided an overview of the different approaches and considerations for preparing test media, the purpose and benefit of toxicity studies, an analysis of issues associated with the purpose, design and communication of results from toxicity studies, and a summary of their most recent research findings on Canadian species.

Discussion

There was a discussion regarding the consideration of droplet size distribution in the prepared solutions and how they may differentially affect the analysis. Other factors considered were the size and scale of the organisms relative to the droplet size.

Droplets smaller than ten microns will quickly lose their soluble components and lose toxicity over time. Small droplets can possibly be enticing as food and ingested by smaller organisms. There were discussions about the challenges in making lab studies relevant to real-world conditions when trying to evaluate the importance of ingestion versus the loss of soluble components.

It is important to clearly document the experimental design and methodology used for toxicity studies. Chemical analysis of prepared test solutions should be completed to provide context for the test conditions and support comparative analysis between different studies. It should be highlighted in the Working Paper that it is correct to normalize concentrations.

WHAT ARE THE POTENTIAL SHORT- AND LONG-TERM IMPACTS ON SENSITIVE RECEPTORS?

Presenter: Rob Willis

Abstract

Dillon presented a summary from their Working Paper, specifically focused on environmental recovery after dispersant use. The presentation reviewed and highlighted the recovery-related findings from past spills and field experiments, broadly discussed how the vulnerability of an organism to oil impacts it’s recovery potential and how the use of dispersants can reduce the potential for long-term impacts.

Discussion

There was a discussion about relevant, Canadian incident examples. The response to the 1970 SS *Arrow* oil spill relied primarily on natural attenuation. The 2019 Hibernia oil spill from storage tanks was used in the presentation as an example for recovery and natural attenuation but this was determined not to be a great example given the scale and complexity of the incident. Instead, the 2018 Husky SeaRose subsea crude oil spill was proposed, which could not be mechanically recovered due to rough weather. The slick was tracked until it was no longer observed (based on aerial observations) after six days because the weather facilitated natural dispersion. The Working Paper will be updated with this example. The Canada-Newfoundland & Labrador Offshore Petroleum Board website was shared with participants, as a repository of information for past spills from platforms in that region.

In the context of shoreline impacts, it was also acknowledged that an entire beach should not be considered as one unit, but instead, divided into unique segments based on species composition, physical attributes, and functions.

REVIEW AND INSIGHTS FROM NON-GOVERNMENT ORGANIZATION RESEARCH

Presenter: Mark Brooks

Abstract

The World Wildlife Fund presented a review of the Working Paper and insights from non-government organization research. The presentation emphasized the need for oil spill response capacity in Canada, the need for science-based decision-making, and the role of Indigenous knowledge holders in supporting response decisions.

Discussion

The participants revisited the issue of the degree to which the laboratory can replicate the real-world, with an emphasis on ensuring lab conditions emulate realistic environmental concentrations.

It was acknowledged that the primary focus is on preventing oil spills. There were some discussions about the response capacities and capabilities available to support large spills in Canada. The value of continuous evaluation and improvement was highlighted. Related to these topics, the Canada-Newfoundland & Labrador Offshore Petroleum Board shared a link to their oil spill conference series, the Spill Prevention and Response Forum. This conference series was specifically focused on response capacity, science, and opportunities for collaboration. In addition, the offshore board website publicly posts contingency plans and lessons learned from past spills.

ENVIRONMENTAL MONITORING CONSIDERATIONS

Presenter: David Creber

Abstract

Dillon presented a summary from their Working Paper, specifically focused on monitoring after dispersant use. The presentation highlighted the need for and distinction between operational and environmental monitoring. A brief overview was presented of existing protocols and best practices, as well as the key questions to address as part of monitoring.

Discussion

No questions arose and no discussion ensued.

REVIEW AND INSIGHTS FROM UNITED STATES ENVIRONMENTAL PROTECTION AGENCY (US EPA) MONITORING PROCESSES

Presenter: Robyn Conmy

Abstract

The United States Environmental Protection Agency (US EPA) presented a review and insights from US EPA monitoring processes. The presentation began with an overview of the regulatory framework in the United States, followed by a summary of the existing guidance for post-dispersant monitoring. The presentation also provided an overview of different monitoring techniques and technologies. Overall, the presentation emphasized the importance of monitoring design and the need for scalability, flexibility, and converging lines of evidence.

Discussion

It was discussed that data collected by each remotely operated underwater vehicle (ROV) can be inserted into the operating platform to obtain real time information with no time delay. NOAA data managers and US EPA geographic information system specialists can load the data into their algorithms to create reports and graphs, which would aid decision-making.

There was a discussion on the topic of oil sniffing dogs. These are dogs that are trained to detect oil in low quantities. While the US EPA does not use them, they have been used in a Canadian context (e.g., North Saskatchewan River spill), and are reflected in existing protocols such as shoreline assessment cleanup techniques (SCAT). They have also been shown to be successful in detecting buried oil (up to 15 feet underground) or under ice.

DISCUSSION AND INITIAL DRAFTING OF SCIENCE ADVICE

Key points were extracted from the Working Paper and served as a guide for discussions. Participant feedback and revisions were directly added to the key points in real time aided by the screen sharing feature in Microsoft Teams. The updated key points were used to create the Summary Bullets to answer the four questions found in the Terms of Reference, forming the basis of the Science Advisory Report.

PLENARY DISCUSSION POINTS

The following points were raised and discussed as part of the plenary:

- Within Canadian legislation, the use of spill treating agents (which are defined to include dispersants) are only available for use as a response tool within the Offshore Petroleum sector. This is most relevant for the east coast of Canada where there are active installations and exploration. Current legislation prohibits their use for any other oil spill source (e.g., ship-source).
- Dispersants generally enhance biodegradation and reduce the environmental persistence of oil spilled in the marine environment.
- Dispersants can be an effective response option when used in accordance with operational guidance and informed by a net environmental benefit determination. They should be considered for use as a primary response tactic, in conjunction with all other viable and technologically feasible tactics (e.g., mechanical, in-situ burning, etc.) to implement the most effective, integrated response.
- Specific to a Canadian context (in particular during the winter), dispersants can be effective in cold (Arctic and subarctic) climates and specific methodologies have been developed for use under these conditions (including for treatment of oil in ice).
- The window of opportunity for the use of chemical dispersants should not be described by pre-defined time frames, as dispersant effectiveness can be highly specific to spill conditions and oil properties. Rather, it should be informed by the oil type, the degree of weathering, and the environmental conditions, which will influence the fate, behaviour, and weathering processes for the oil (before dispersant use) and the dispersed oil droplets (after dispersant use). It is acknowledged, however, that this window of opportunity is typically short (i.e., hours or days) and effective preparedness best supports timely and informed decision-making processes.
- When applied to oil slicks on the surface of the water, dispersants act by reducing the oil-air and oil-water interfacial tensions so that when mixing energy is added (typically from waves,

but conceivably from other sources such as ship thrusters), small droplets break away from the slick, move downward into the water column where they stay suspended, and spread beneath the surface over a larger volume of water.

- This process facilitates the transfer of oil from the sea surface into the water column (or when used subsea, they facilitate the retention of oil in the water column), where smaller oil droplets can be rapidly diluted to low concentrations and be more readily available for microbial degradation.
- It is acknowledged that toxicity thresholds are not known for all species, in particular species at risk or high trophic level species. Any knowledge gaps or uncertainties must be considered in the decision-making process for the selection of oil spill response options including that of dispersant use.
- It is recognized that preparedness efforts, access to critical knowledge and expertise, and timely but informed decision-making and mobilization of assets are of critical importance for the protection of the environment for all response measures, including dispersants.

SCOPE

- Most chemical dispersants function in the same way; however, with ongoing research and development, formulations (e.g., gel-based) and their mode of action (e.g., enzyme-based) are expected to evolve. The scope of this process is not limited to any specific formulation or product. Instead, it speaks to the broad modes of action that are applicable across most commercially available formulations.
- For the purposes of this process, it was determined that the addition of clay-based mineral fines as a response measure would better fit under the category of “oil translocation” rather than “dispersants” and was not specifically discussed.
- It is critical that the premise of dispersant use be effectively communicated to regulatory decision-makers, elected officials, the media, and the public in advance of an oil spill to avoid misunderstandings during a response, which is what this process is striving to achieve.
- It is equally important that all stakeholders have a clear understanding of the decision-making process and requirements for the authorization of dispersant use in Canada. While this aspect is outside the scope of this process, it was an important consideration as acknowledged by participants throughout the discussions.

REASONS TO CONSIDER DISPERSANTS

- In a surface application context, chemical dispersants:
    - Provide a response tool that can be rapidly applied at the speed of an aircraft, whereas other response tools require application by boat;
    - Have a higher encounter rate than other response options because of the speed of aircraft operations, which is particularly important for large, offshore oil spills where mechanical recovery is less effective;
    - Can support a more efficient and effective response compared to other response options depending on the oil type and the environmental conditions;
    - Offer an option when environmental constraints (e.g., wind speed and wave-height) or slick thickness inhibit the effective use of other response tools;
    - Are safer to deploy in challenging weather conditions (relative to other response measures), which is particularly applicable to Canadian context;

- Reduce the amount of oil in surface slicks. This also reduces evaporation and protects both responders and surface-dwelling organisms from fumes;
- Reduce the probability of oil slicks being transported to susceptible nearshore or shoreline environments (e.g., intertidal mudflats) where the persistence of residual oil is greater;
- Reduce the oil-air and oil-water interfacial tensions, which combined with energy, promote a reduction in oil droplet size;
- Increase dispersion, dissolution, and dilution of oil droplets over a greater volume of water;
- Enhance (natural) biodegradation; and,
- Can reduce or prevent water-in-oil emulsions.

- In a subsea dispersant injection (SSDI) application context, chemical dispersants:
  - Offer a more effective and targeted approach, requiring less dispersant use;
  - Have a much higher encounter rate than for surface application;
  - Have the potential of treating 100% of the oil before it has spread into the environment;
  - Can be applied 24/7 and in any sea state/weather conditions (important consideration for winter conditions in Canada with short daylight periods);
  - Reduce surface slicks (thereby also reducing volatile emissions into the atmosphere) and protect both responders and surface-dwelling organisms;
  - Reduce oil droplet size;
  - Increase dispersion, dissolution and dilution of oil droplets over a greater volume of water; and,
  - May enhance (natural) biodegradation of oil at depth (depending on incident, scenario, and environmental conditions).
- It should also be noted that subsea injection is an application method that could be used at any depth. It is not only relevant for deep sea well blowouts.

EFFICACY

- It was recommended that any time a dispersant is considered as a response measure, a field test should be conducted to confirm efficacy based on the site-specific conditions, prior to its application at an operational scale.
- An understanding of the physical and chemical properties of the spilled oil/hydrocarbon product, the degree of weathering, and the timelines for potential deployment are important for an initial consideration of chemical dispersant suitability and viability. Specific oil properties to consider include:
  - Density (often expressed as API Gravity);
  - Degree of weathering;
  - Viscosity or rheology;
  - Pour point; and,
  - Slick thickness (important for surface application).
- The optimal use of dispersants is on freshly released, light crude oils and some medium crude oils. While dispersants may be effective on very light oils, they are typically not required due to rapid rates of evaporation, natural dispersion, and other oil weathering processes. Dispersants are generally less effective on oils that are very viscous, likely to emulsify, or that are at temperatures 10–15ºC below their pour point.

INFORMED DECISION-MAKING

- A decision to use a dispersant should be based on the results of a net environmental benefit analysis (NEBA); a decision-making framework and communication tool that examines and balances the trade-offs associated with leaving the spilled oil untreated or treated by other means.
- A NEBA takes into consideration the:
  - Oil properties;
  - Incident scenario and location;
  - Environmental conditions;
  - Degree of weathering;
  - Dispersant type;
  - Outcomes of a field test;
  - Resources at risk (which can include consideration at the individual level, for example for *Species at Risk Act* (SARA) species); and,
  - Balancing of trade-offs between the available protection priorities.
- The objective of a NEBA is to determine the response option(s) that offers the optimal benefit for the protection of the ecosystem that is predicted to be impacted by an oil spill.
- Operationally, when determining which response tools to assess, some of the key considerations for informed decision-making can include:
  - Dispersant type and availability of stockpiles and assets for application (e.g., Corexit EC9500A);
  - Operational constraints (e.g., daylight hours, water depth, temperature, salinity, and availability of personnel/equipment for application);
  - Environmental conditions (e.g., wind, waves, currents, presence of ice); and,
  - Implications for other, parallel response strategies (e.g., will the use of chemical dispersants hinder other shoreline protection strategies).
- Specific to a Canadian context, the characteristics of cold water environments (including lower air temperatures, colder water temperatures, the presence of ice, and shorter daylight periods) can influence the fate and behaviour of spilled oil and subsequently impact decisions about the potential use of chemical dispersants. When oil is released in the presence of sea ice, several interactions can occur, including:
  - Oil deposition onto the ice surface;
  - Oil absorption into snow;
  - Oil encapsulation into the ice;
  - Oil becoming trapped in leads or in open water fields between floes;
  - Oil becoming trapped under ice in ridges and keels; and,
  - Oil building up along and becoming trapped in landfast ice edges.

TERMS OF REFERENCE OBJECTIVE #1

The following section summarizes the discussion related to this Terms of Reference objective: How does applying dispersants change the movement of oil and exposure to sensitive receptors (e.g., aquatic species, habitats and other sensitive coastal or marine areas)?

PLENARY DISCUSSION POINTS

The following points were raised and discussed as part of the plenary:

- For the purposes of this process, it should be clarified that when referring to “dispersed oil”, this specifically refers to chemically treated oil (not naturally dispersed oil).
- Dispersants can be applied to oil slicks on the surface of the water (e.g., from surface vessels or aircraft) or through subsea dispersant injection (SSDI) into a plume of oil released from below the surface (e.g., blowout).

FATE AND BEHAVIOUR OF DISPERSED OIL

- There is an understanding that oils that are dispersed (naturally or chemically) will dilute and naturally biodegrade over time.
- When applied to oil slicks on the sea surface, dispersants fragment oil into smaller droplets, which, in combination with wave energy, promotes vertical movement of the droplets into the upper water column. From there, waves, tides, and currents promote the horizontal and vertical movement, dispersion, dissolution, and biodegradation of those particles.
- When applied using SSDI, dispersants decrease the size of the droplets formed at the source, slowing their rise to the surface, increasing biodegradation and dissolution, and preventing or reducing the formation of surface slicks. In cases where trap height is present, a portion of dispersed and dissolved oil may get trapped within an intrusion layer. In cases of SSDI, more dispersed oil may be found in this layer.
- The dilution of the soluble components of oil following the use of dispersants (by either method) also reduces the potential for spatial interactions between oil droplets and the potential for recoalescence.
- In terms of mode of action, dispersants on the surface of oil droplets promote tip-streaming, the formation of microthreads due to the deformation of droplets from shear stress as they move through the water column. This action results in the formation of microdroplets.
- Oil degrading microorganisms are ubiquitous (including in cold and deep-sea environments).

MODELLED PREDICTIONS

- It was acknowledged that the rate of energy dissipation is an important modelling consideration. It is important to note that even on calm days, the presence and influence of eddies and currents will produce significant levels of advection and cross-flow that contribute to the mixing of the water column, including under ice.
- Models can be used as a communication tool and a decision-support tool to predict and forecast the outcomes of a spill and/or the associated response actions. Models are used to make predictions in the short-term. Over time, improvements are continuously made as they are further validated and refined as new information and considerations are integrated, which help inform trade-off decisions and operational decisions.
- Different trajectory models are sometimes used to model different types of release (e.g., surface versus subsurface). Similarly, there are different models used depending on whether contingency planning, operational spill modelling, or environmental impact modelling are being considered. Each model has slightly different approaches and degrees of complexity, with advantages and disadvantages. The input requirements can also vary depending on the specific model and the intended use. It was also acknowledged that the quality of the model outputs are contingent on the quality of the input data layers.

- Laboratory and field experiments, as well as real-world observations, support the ongoing refinement of existing trajectory models to predict the fate and behaviour of dispersed plumes.
- Marine snow occurs naturally in the ocean due to organic detritus or living microbes forming aggregates that sink and deposit on the ocean floor. When oil associates with marine snow, it is more likely to settle to the seafloor. Existing tools and models allow incorporation of marine snow (or predictors such as particle numbers) and inform decision-making processes (as required).
- The information required to appropriately forecast the fate/behaviour of a dispersed plume includes:
  - Oil droplet size (e.g., diameter);
  - Environmental conditions that influence where the oil droplets will go; and,
  - Rate of dissolution of the soluble components into the water column.
- There is a need to enhance the transparency and effectively communicate how knowledge gaps and uncertainties are addressed within models. Some specific examples related to organism impacts include taking a conservative approach by:
  - Estimating higher volumes of oil than may be in environment;
  - Assuming the highest concentrations of dispersed oil in the water;
  - Assuming the presence of populations of concerns (which may not be there);
  - Assuming the presence of the most sensitive life stages in high numbers;
  - Applying thresholds that protect 95% of all the organisms which assumes these organisms are a lot more sensitive than they actually are;
  - Assuming that organisms are affected even where models show they would only be exposed for very short durations (e.g., minutes);
  - Assuming all individuals exhibit acute mortality, immediately; and,
  - Applying conservative population restoration rates.

FATE OF DISPERSANTS

- There is a desire and a need to be able to effectively communicate where the dispersant has gone over time.
- The concentration of dispersant associated with the oil will change over time. There appear to be the following general scenarios; however, this is an area for additional research:
  - Shedding of dispersants due to shear (i.e., tip-streaming);
  - Leaching of surfactant molecules from oil droplets;
  - Surface retention in the slick; and,
  - Retention frozen in the ice (has been show to retain effectiveness until spring melt).

SENSITIVE RECEPTOR EXPOSURE ROUTES

- Fragmenting the oil into smaller droplets and spreading them into the water column over a larger volume of water changes the dose, concentration, duration, and routes of exposure (i.e., means by which a contaminant enters an organism) for receptors.
- As a result of dispersion, the concentrations of oil droplets and dissolved oil may be lower over time in a dispersed oil plume compared to oil components in the near vicinity of a surface slick.

- Smaller oil droplets also have a larger surface area to volume ratio which increases microbial colonization and supports enhanced biodegradation.

SOURCES OF UNCERTAINTY

- Understanding how knowledge gaps and uncertainties are integrated into models and decision-making considerations.
- Understanding the inputs, gaps, and assumptions made for a model is critical for the interpretation of the results. For example, understanding whether site-specific wind patterns are integrated into a trajectory model is helpful to determine the level of confidence in the surface trajectory model outputs.

TERMS OF REFERENCE OBJECTIVE #2

The following section summarizes the discussion related to this Terms of Reference objective: What are the differences in exposure and effects between untreated oil and dispersed oil and their potential short- and long-term impacts on sensitive receptors?

PLENARY DISCUSSION POINTS

The following points were raised and discussed as part of the plenary:

- It is important to be reminded that the context for the consideration of dispersants is an oil spill where other response measures and natural dispersion are not expected to be sufficient to effectively mitigate the impacts from the spill. Oil droplets naturally disperse and biodegrade over time, but the dispersant response tool offers an option to further enhance and expedite these processes. The limitations of mechanical recovery for large spills mean that the vast majority of the oil will remain in the environment, allowing natural processes to determine the oil fate. However, effective use of dispersants allows responders to influence the fate of oil to protect surface dwelling wildlife and avoid stranding of oil on sensitive shorelines.
- In response to these interactions, different dispersant application methods may be required. Chemical dispersants have been demonstrated to be an effective response option, even in cold climates where biodegradation rates have been proven to frequently be faster with dispersant as compared to natural attenuation.
- It is important that lab-based toxicity studies accurately report the concentrations of oil that organisms experience over time. Canadian efforts are underway to define and characterize minimum measured chemistry and toxicity data reporting standards.
- It is important to effectively communicate dispersant toxicity and impacts. All studies need to be comparable and consistently considered, which is to say that exposures need to be considered (i.e., report measured exposures over time versus nominal exposure). This is an important consideration when examining and interpreting dispersant toxicity studies.

MECHANISMS FOR EXPOSURE

- Exposure pathways (i.e., the means by which an organism comes into contact with oil) for aquatic organisms between non-dispersed oil and chemically-dispersed oil are the same; however, the use of chemical dispersants may alter the amount and duration of exposure for individual organisms depending on their relative interactions with shorelines, surface water, water column, and/or benthic zones.

- The main mechanisms for exposure (i.e., exposure routes) of aquatic organisms (examined in the context of Canadian species) include the following:
  - Inhalation of aerosols and volatile substances present in dispersed oil;
  - Aspiration of dispersed oil at water surface;
  - Direct absorption and/or dermal contact from direct sea water, porewater, sediment, and/or droplet contact;
  - Uptake from sediments and sediment porewater; and/or,
  - Ingestion of food, prey, water, sediment, detritus, and/or droplets.
- Understanding the spatial and temporal potential for exposure of key species between untreated oil and dispersed oil is important for decision-making processes and trade-off analysis (i.e., net environmental benefit).

CHANGES IN EXPOSURE WITH DISPERSANT USE

- By diluting, diffusing, and dispersing smaller oil droplets over a larger volume of water, the use of dispersants reduces the potential exposure of aquatic organisms on the surface and on shorelines (including intertidal and subtidal) but temporarily increases potential exposure in the water column (by increasing the proportion of oil in that compartment and increasing the spatial scale/distribution).
- Improved understanding of exposure routes is more effectively achieved through modelling rather than field measurements due to challenges associated with field data collection and the need to capture timely dissolved phase concentrations.
- Relative to non-dispersed oil, the use of dispersants (including in cold climates) would be expected to result in:
  - Lower proportions of oil at the water surface and available to strand on shorelines (including intertidal and subtidal);
  - Higher proportions of oil droplets in the water column;
  - An increase in dissolved or water-accommodated oil-associated fractions in the water column; and,
  - An increase in the bioavailability potential of oil-associated substances.
- Many of the aquatic resources that are most sensitive to oiling utilize the surface water and/or shoreline (including intertidal and subtidal) environments. Oil residues can persist for long periods of time in shoreline and intertidal/subtidal areas which may chronically effect marine organisms. The use of dispersants helps to reduce the persistence of oil and the potential exposure to these sensitive areas.

CONCENTRATION AND DURATION

- Dispersants function to break up oil into smaller droplets and micro-droplets, which have a larger surface area to volume ratio than untreated oil droplets. As a result, the bioavailability of oil-associated contaminants to marine organisms is temporarily increased with the use of dispersants; however, these aqueous concentrations are also rapidly diluted.
- Current research and reviews from recent spills (such as the DWH) suggest the use of dispersants rapidly dilutes aqueous concentrations of oil substances below known, lab-derived 48 and 96 hour acute toxicity thresholds, despite the increased bioavailability potential. It is, however, acknowledged that such thresholds don’t exist for many of the legally protected/listed species, the potential exists for acute sub-lethal effects, and that delayed lethal and sub-lethal effects may be observed following the spill.

MECHANISMS FOR EFFECTS AND IMPACTS

- Overall, reducing the concentration, duration, and magnitude of exposure to aquatic resources from dispersed or non-dispersed oil, and preventing the oiling of shorelines/intertidal/subtidal areas (which are more difficult to clean), will reduce the potential for delayed effects and/or long-term impacts.
- In general, the effects and impacts of dispersed oil on marine biota are highly variable and are a function of the:
  - Exposure pathways;
  - Degree and duration of exposure;
  - Concentrations of oil substances in the exposure media;
  - Bioavailability of the petroleum hydrocarbons to the exposed marine organisms; and,
  - Sensitivity of the species.
- Potential population-level impacts as opposed to individual organism effects (abnormal behaviour, growth inhibition, low body weight, reduced fitness, reproductive failure, infection, and mortality) are the key metrics for consideration as indicators of environmental effects (or individual-level impact when considering species at risk). The importance and consequences for habitat (including Critical Habitat), trophic level, and environmental compartment interactions (ecosystem functions/ services) are also critical considerations to inform decision-making processes about the potential use of dispersants.
- Specific mechanisms of impact are important for hazard, risk, and damage assessments, and can be used to inform model predictions. However, information on the mode of action is less relevant than the level of environmental impacts for operational, spill-response decision-making.
- Cold water species generally have similar sensitivity as temperate species to oil-associated substances (in both untreated and dispersed oil) in relation to acute effects (chronic effects are less well characterized between cold water and temperate species), but as a result of morphological and physiological adaptations, cold water species may take longer than temperate species to exhibit the effects of oil or dispersed oil exposure. However, exposures in ice-infested water may also be longer than in temperate waters because of delays in response time and difficulties in clean up operations.

IMPLICATIONS FOR ENVIRONMENTAL RECOVERY

- The ability of a community/population to recover following an oil spill event is dependent on the:
  - Oil type;
  - Degree of weathering;
  - Duration and extent of exposure;
  - Dose/concentration of oil;
  - Proportion of individual organisms or populations interacting with the dispersed oil;
  - Sensitivity/resilience of the organisms and/or habitat;
  - Severity of impacts on sensitive species; and,
  - Numbers affected.
- The long-term recovery of a population following an oil spill is dependent on a variety of species-specific factors, including:
  - Sensitivity of individual organisms;

- Habitat health;
- Population status;
- Reproductive capacity;
- Geographic range within the region;
- Ability to metabolize, excrete, or otherwise remove hydrocarbons; and,
- Close association with sediments.

- Real-world spill examples have demonstrated that the use of dispersants has contributed to the recovery of sensitive ecosystems more than it has adversely impacted overall ecosystem health.

SOURCES OF UNCERTAINTY

- There are large databases of dose-response curves / toxicity information (e.g., NOAA CAFE) but limited data on mammals, reptiles, birds, and species at risk.
- Evidence from past spills and predictive modelling can provide a general understanding of how exposure can negatively impact commonly studied organisms, but additional research would help further refine the models (e.g., sensitivity for birds exposed to dispersed oil under the water; the influence of behaviour on potential exposure pathways) and there remain significant knowledge gaps related to marine mammals, reptiles, and birds (e.g., susceptibility to the effects of dispersed oil and avoidance behaviour).
- There remains some uncertainty about which specific constituents of oil are critical for understanding the potential impacts from dispersed oil.

TERMS OF REFERENCE OBJECTIVE #3

The following section summarizes the discussion related to this Terms of Reference objective: What are the key considerations or recommendations for environmental monitoring after dispersant use?

PLENARY DISCUSSION POINTS

The following points were raised and discussed as part of the plenary:

- Canada has a strong marine safety system, with a strong emphasis on prevention and preparedness. The regime is founded on a polluter pay principle, which establishes responsibilities and liability limitations for spill incidents.
- Each response tool has strengths, weaknesses, and operational limitations. Response efforts should seek to consider the use of all viable measures and tools, informed by the location, size, scale, magnitude, risk, and complexity of the incident.

INFORMED DECISION-MAKING

- This CSAS process is specific to DFO Science Advice but acknowledges and recognizes that decisions are informed by multiple partners.
- A NEBA should be informed by the best available information, scientific and technical expertise, as well as engagement from response partners and regulators.
- Potential impacts on species at risk, their residences and identified Critical Habitat (defined in sections 32, 33 and 58 of the *Species at Risk Act*), and the intent of those (and other legal protections for marine species) must be considered when informing a decision about

dispersant use. If specific knowledge gaps on exposures/effects/impacts exist, then this must also be made clear, and conservative assumptions on potential effects to these species should be used in decision-making.

- The potential for dispersed oil to destroy Critical Habitat in terms of the geographic area and the functions, features, and attributes must be explicitly considered (in accordance with the legislation).

CHANGES IN EXPOSURE WITH DISPERSANT USE

- The determination about the potential forecasted changes in spatial extent of untreated oil versus chemically-dispersed oil needs to be supported by site-specific trajectory models that take into account differences in the fate and behaviour of the oil over the entire life of the spill.

SENSITIVE RECEPTOR EXPOSURE ROUTES

- Some of the critical information to enable an understanding of receptor exposure routes and potential effects and impact include (NASEM, 2020):
    - Comparison of time-varying exposure in the real-world to known acute or chronic toxicity thresholds for the specific oil and for the species of concern;
    - Duration of exposure and extent of distribution above this toxicity threshold;
    - Spatial and temporal distribution of species of concern;
    - Species sensitivity to oil exposure above the acute or chronic toxicity thresholds; and,
    - The potential for delayed effects.

PREPAREDNESS AND DATA REQUIREMENTS

- For any significant spill, significant challenges include data needs and intended uses, transmission, storage, interpretation and analysis, management, and communication. Opportunities for automation and pre-planned integration into data sharing platforms (e.g., Common Operating Picture) are strongly encouraged.
- Specific to preparedness, the following data/knowledge/information would be beneficial to support timely, informed response decisions:
    - Comprehensive contingency plans, developed and supported by stakeholders (e.g., response partners, resource managers, traditional knowledge keepers, etc.);
    - Seasonality (e.g., timing windows, migration, fishing periods, etc.);
    - Baseline hydrodynamics (e.g., tides, currents, weather, etc.);
    - Baseline environmental, ecological, and biological data/resources of a specific region including Traditional Knowledge, if available;
    - Baseline data on contaminant concentrations (including dissolved and organic matter, hydrocarbon, metals, other pollutants, emerging and persistent contaminants, etc.) across various media;
    - Baseline shoreline delineations and characterizations (e.g., pre-SCAT surveys);
    - Consolidated knowledge about sensitivities, vulnerability, and recovery potential for Canadian species to both oil and dispersed oil;
    - Economic, social, recreational, and indigenous data/resources of a specific region (leveraging an ecosystem services approach to the extent possible); and,
    - Specific to areas where subsea dispersant use could be considered (e.g., offshore), proactively consider what resources (e.g., recreational, economic, biological, ecological) are potentially at risk and integrate them into preparedness plans.

- Timeliness of data, information, and decisions are critical. Other international jurisdictions (e.g., United States, United Kingdom, France) have decision-making frameworks and preparedness/contingency plans (with specific response tools identified for consideration by geographically delineated area) that support timely decision-making by integrating, in advance of an incident:
  - Operational constraints;
  - Planning;
  - Training
  - Communication; and,
  - Stakeholder engagement.

MONITORING REQUIREMENTS, METRICS, AND KEY CONSIDERATIONS

- There are two key components to monitoring specifically associated with dispersant use:
  - Operational Monitoring: associated with evaluating the use and effectiveness of dispersant application and against specific shut-down criteria (e.g., locations, durations, estimated efficacy, etc.).
  - Environmental Monitoring: associated with measuring and examining potential environmental effects including evidence of recovery. It involves activities that collect and compile environment data over months or years that characterize the conditions in a region where dispersants may be applied or have been applied.
- There are currently no specific Canadian standards or protocols for dispersant monitoring in the offshore. International standards and industry best practices are commonly referenced within contingency plans for offshore platforms in Canada. Such contingency plans are updated by industry on a regular basis (related to their operational authorizations) to integrate new data, knowledge, technology, and monitoring plans. The contingency plans are reviewed by the offshore petroleum boards and used for exercises.
- Monitoring needs are entirely dependent on the specific spill scenario and the potential risks and resources that could be impacted, as well as the scale, scope, and complexity of the spill.
- All monitoring should include the consideration and analysis of both untreated and chemically-dispersed oil in order to enable comparative analyses.
- Specific to operational monitoring, it should be acknowledged that the SMART protocol from the United States is focused on operational effectiveness and is intended for surface application and short durations of dispersant use (less than 96 hours). The Prolonged Surface Application Guidance should be considered for longer uses (which begins to integrate environmental considerations) and the Subsea Application Guidance should be considered for subsea applications.
- It is acknowledged that most dispersant operations happen quickly and for a short period of time (less than 96 hours). In these cases, aerial/visual observations and vessel radar technology may be the only suitable and accessible monitoring options available (in particular within remote locations). This information is critical to inform all operational response decisions (including both dispersant and untreated scenarios).
- Monitoring activities depend on:
  - Type, quantity and volume of oil released;
  - Fate and trajectory of the oil;

- What resources will be exposed to dispersed oil and how they will be impacted;
  - Mitigation/response strategies; and,
  - Available baseline information.

- Environmental monitoring should examine the movements and behaviours of sensitive receptors during the response operations in order to observe, validate, and better understand how the organisms interact with the spill and support the refinement of models, protocols, and impact assessment approaches.

- Where possible, it is recommended to use the optimal excitation and emission wavelengths for fluorometric analysis of the oil.

- Post-spill environmental monitoring should include such considerations as:
  - Visual observations (photo, video, etc.) which inform endpoints and restoration;
  - Site characterization and changes over time;
  - Passive sampling (which could include monitoring for the leaching of dispersants from oil over time);
  - Source oil sampling;
  - Water sampling and monitoring;
  - Sediment sampling and monitoring;
  - Habitat characterization/validation;
  - Species presence and data validation; and/or,
  - Environmental monitoring endpoints (determined by the impacts and recovery of marine life in the area along with the details involved around the spill scenario).

- The use of new tools and technologies (e.g., AUV, ROV, canines, remote sensing, etc.) are encouraged to:
  - Ensure rapid deployment;
  - Enhance the ability to detect oil;
  - Enhance opportunities for near real-time data analysis and communication;
  - Enable 24/7 capabilities;
  - Support monitoring multiple, concurrent metrics; and,
  - Support intentional and self-directed sensor movements (compared to drifters for example).

MONITORING RESULT INTERPRETATION

- Spills are unique and dynamic and continue to change over time. Monitoring data are only useful if the outcomes and results from the monitoring can be communicated in an efficient and effective way. Being able to integrate the data real-time or near real-time is critical to inform decision-making processes. Understanding the data in its full context is equally important, as is the understanding that data can be interpreted differently in hindsight.

- Information obtained through operational monitoring enables:
  - Iterative re-evaluation of the net environmental benefit determination;
  - Re-examination of the use of dispersants to meet specified response objectives;
  - Refinement and adjustment of operational tactics and strategies;
  - Effective use, validation, and calibration of specific tools and monitoring instruments; and,
  - Opportunities to refine models and existing research.

- In addition to those listed for operational monitoring, information obtained through environmental monitoring enables:

- Re-examination of protection priorities and response objectives; and,
- Scoping of long-term monitoring requirements.

SOURCES OF UNCERTAINTY

- Species at risk (Extirpated, Endangered, Threatened) are protected at an individual level and have prohibitions against killing, harming, or harassing them, damaging or destroying their residences, and destroying any part of their identified Critical Habitat. Uncertainties and knowledge gaps on species-specific toxicity thresholds, exposure pathways (direct, indirect), and short-term and long-term impacts must be appropriately considered given the legislative duties towards them and their Critical Habitat, and the potential for dispersant application to contravene the associated prohibitions or jeopardize the survival or recovery of a SARA-listed species.
- There are limitations on the range and effectiveness and interference for each sensor used for monitoring, which highlights the importance of the convergence of lines of evidence.
- There remains some general uncertainty (not specific to spill response) as to whether the use of AUV/ROV technologies/tools temporarily attracts specific species (e.g., dolphins, sharks).

TERMS OF REFERENCE OBJECTIVE #4

The following section summarizes the discussion related to this Terms of Reference objective: What are the priority, outstanding science needs to support the regulatory regime and decision-making for the use of dispersants in Canada?

The complete list of identified future science needs is reflected in the Science Advisory Report for this process entitled "State of Knowledge on Chemical Dispersants for Canadian Marine Oil Spills".

APPENDIX 1: TERMS OF REFERENCE

State of Knowledge on Chemical Dispersants for Canadian Marine Oil Spills

National Advisory Meeting – National Capital Region

March 1-12, 2021
Virtual Meeting

Co-Chairs: James McCourt (SL Ross) and Lisa Setterington (DFO Ecosystems and Oceans Science)

Context

Canada has a strong marine safety system focusing around four major pillars: prevention; preparedness and response; liability and compensation; and recovery. In recent years, the Government of Canada has dedicated significant resources to further enhance specific aspects of the environmental protection and Emergency Response regime in Canada.

When there is an oil spill in the marine environment, Fisheries and Oceans Canada and the Canadian Coast Guard use science-based advice to inform decisions that facilitate cleanup and protect aquatic resources and ecosystems from negative impacts.

Following an oil spill, there is a need to assess and evaluate the effectiveness of all available response tools that could reduce the potential for adverse effects on marine ecosystems, including the consideration of spill treating agents such as chemical oil dispersants. Since the Deepwater Horizon spill in the Gulf of Mexico, there has been extensive research and scientific advancement related to dispersant use. This recent scientific information, available through various fora, has not yet been critically evaluated specific to its applicability within a Canadian context.

Objectives

The goal of this science peer review meeting is to consolidate, assess and critically evaluate the current state of knowledge on dispersants as it applies to a Canadian context. Specific questions to be addressed by this National peer review meeting include:

1. How does applying dispersants change the movement of oil and exposure to sensitive receptors (e.g., aquatic species, habitats, and other sensitive coastal or marine areas)?
2. What are the differences in exposure and effects between untreated oil and dispersed oil and their potential short and long-term impacts on sensitive receptors?
3. What are the key considerations or recommendations for environmental monitoring after dispersant use?
4. What are the priority, outstanding science needs to support the regulatory regime and decision-making for the use of dispersants in Canada?

The outcomes from this process are expected to be used to:

- efficiently inform critical and time sensitive spill response decisions (such as net environmental benefit determinations);
- provide consensus-based, scientific advice to inform and support the communication of spill response decisions;
- support and inform the development of regulations, policies, standards and guidance for dispersant use; and,

- support various other Government of Canada initiatives related to spill response.

Expected Publications

- Science Advisory Report
- Proceedings
- Research Document

Expected Participation

- DFO Science
- DFO Aquatic Ecosystems
- Canadian Coast Guard
- Environment and Climate Change Canada
- Transport Canada
- Natural Resources Canada
- Academics
- Industry, as appropriate
- Other invited experts, such as SL Ross, Dillon Consulting Ltd. and others, as appropriate

APPENDIX 2: AGENDA

Fisheries and Oceans Canada
Canadian Science Advisory Secretariat (CSAS)
National Science Advisory Workshop

AGENDA – State of Knowledge on Chemical Dispersants for Canadian Marine Oil Spills

Chairpersons: James McCourt (SL Ross) and
Lisa Setterington (DFO Ecosystems and Oceans Science)

Location: Virtual

March 1 to 12, 2021

Virtual Details:

Specific questions to be addressed by this National peer review meeting include:

1. How does applying dispersants change the movement of oil and exposure to sensitive receptors (e.g., aquatic species, habitats, and other sensitive coastal or marine areas)?
2. What are the differences in exposure and effects between untreated oil and dispersed oil and their potential short and long-term impacts on sensitive receptors?
3. What are the key considerations or recommendations for environmental monitoring after dispersant use?
4. What are the priority, outstanding science needs to support the regulatory regime and decision-making for the use of dispersants in Canada?

CSAS Meeting: Part 1 – Current State of the Science

	Time	Monday March 1, 2021	
1	11:00 – 11:15 EST	Introductions	James McCourt (SL Ross)
2	11:15 – 11:30 EST	Overview / Review of the Terms of Reference / Scope boundaries and Virtual Meeting Housekeeping	
3	11:30 – 11:45 EST	Introduction to the CSAS Process and Policies	Lisa Setterington (DFO)
4	11:45 – 12:00 EST	Overview of the Canadian Response Regime	CCG
5	12:00 – 12:30 EST	Presentation: Foundational Dispersant Science	Dillon
	12:30 EST	Break (15 mins)	
6	12:45 – 1:00 EST	Presentation: Review and Insights from Industry-led Research	Tim Nedwed (Exxon)
7	1:00 – 1:15 EST	Presentation: Review and Insights from Industry-led Research	Victoria Broje (Shell)
8	1:15 – 1:30 EST	Presentation: Review and Insights from Deepwater Horizon / GoMRI	Gina Coelho (BSEE)
9	1:30 – 2:45 EST	Discussion and Initial Drafting of Science Advice • Key Question #1: How do dispersants work? What's the premise for dispersant use? Why would you use them? Do all dispersant products function in the same way? • Key Question #2: What type of hydrocarbon/oil can be dispersed? • Key Question #3: What are the considerations to inform a decision about whether to consider the use of dispersants? • Key Question #4: What are the priority, outstanding science needs? • Science Advice: TOR Question #4: What are the priority, outstanding science needs to support the regulatory regime and decision-making for the use of dispersants in Canada?	Co-chairs
10	2:45 – 3:00 EST	Discussion Wrap-up / Summary	

CSAS Meeting: Part 2 – Fate and Behaviour

	Time	Wednesday March 3, 2021	
1	11:00 – 11:15 EST	Overview and Objectives for this Session	James McCourt (SL Ross)
2	11:15 – 12:00 EST	Presentation: Fate and Behaviour	Dillon
	12:00 EST	Break (15 mins)	
3	12:15 – 12:30 EST	Presentation: Review and Insights from COOGER's Research	Tom King (DFO)
4	12:30 – 12:45 EST	Presentation: Review and Insights from Academic Research	Michel Boufadel (NJIT)
5	12:45 – 2:45 EST	Discussion and Initial Drafting of Science Advice • Key Question #5: What is the expected fate and behaviour of dispersed oil and it's degraded products in the environment? • Key Question #6: What's the evolution, fate and distribution of oil droplets over space and time? How does it influence the constituents and bioavailability over space and time? • Key Question #7: What do we know about what happens to a dispersed plume over the long-term? How do processes such as the formation of marine oiled snow factor into our decision-making? • Key Question #8: What information is required to appropriately forecast the fate/behaviour of a dispersed plume? • Science Advice: TOR Question #1: How does applying dispersants change the movement of oil and exposure to sensitive receptors (e.g., aquatic species, habitats, and other sensitive coastal or marine areas)? • Science Advice: TOR Question #4: What are the priority, outstanding science needs to support the regulatory regime and decision-making for the use of dispersants in Canada?	Co-chairs
6	2:45 – 3:00 EST	Discussion Wrap-up / Summary	

CSAS Meeting: Part 3 – Exposure

	Time	**Friday March 5, 2021**	
1	11:00 – 11:15 EST	Overview and Objectives for this Session	James McCourt (SL Ross)
2	11:15 – 11:30 EST	Recap on the Discussion about Fate and Behaviour	Dillon
3	11:30 – 12:00 EST	Presentation: How the Application of Dispersants Can Alter the Pathways for Exposure	
	12:00 EST	Break (15 mins)	
4	12:15 – 12:30 EST	Presentation: Review and Insights from the United States Natural Resource Damage Assessment Experience	Douglas Helton (NOAA)
5	12:30 – 2:45 EST	Discussion and Initial Drafting of Science Advice • Key Question #9: How does the use of dispersants impact the concentration and duration of exposure of oil for aquatic organisms? • Key Question #10: What are the broad mechanisms for exposure from dispersed oil? • Key Question #11: How does the use change the exposure of the dispersed oil? How do they impacts the availability of the dispersed oil in aquatic ecosystems? • Key Question #12: How are the different elements of the ecosystem exposed? What are the mechanisms for exposure? (direct, indirect, lethal, sub-lethal, etc.) • Science Advice: TOR Question #2: What are the differences in exposure and effects between untreated oil and dispersed oil and their potential short and long-term impacts on sensitive receptors? • Science Advice: TOR Question #4: What are the priority, outstanding science needs to support the regulatory regime and decision-making for the use of dispersants in Canada?	Co-chairs
6	2:45 – 3:00 EST	Discussion Wrap-up / Summary	

CSAS Meeting: Part 4 – Effects

	Time	Monday March 8, 2021	
1	11:00 – 11:15 EST	Overview and Objectives for this Session	James McCourt (SL Ross)
2	11:15 – 11:45 EST	Presentation: What are the differences in and effects between untreated oil and dispersed oil	Dillon
3	11:45 – 12:15 EST	Presentation: Review and Insights Related to Dispersed Oil Toxicity	Benjamin de Jourdan (Huntsman)
	12:15 EST	Break (15 mins)	
4	12:30 – 1:00 EST	Presentation: What are the potential short and long-term impacts on sensitive receptors	Dillon
5	1:00 – 2:45 EST	Discussion and Initial Drafting of Science Advice • Key Question #13: Is chemically dispersed oil more toxic than the oil itself? • Key Question #14: What's the current state analysis on the different mechanisms of impact to aquatic species? • Key Question #15: What are the different mechanisms for impact? How does the use of dispersants change the physical response and recovery potential of a species? How does it affect the potential for long-term impacts? • Key Question #16: How does the use of dispersants change the bioavailability of the dispersed oil and how does that differentially affect aquatic species? • Key Question #17: Would the use of dispersants change the potential recovery of the species or is it more based on exposure potential? • Science Advice: TOR Question #2: What are the differences in exposure and effects between untreated oil and dispersed oil and their potential short and long-term impacts on sensitive receptors? • Science Advice: TOR Question #4: What are the priority, outstanding science needs to support the regulatory regime and decision-making for the use of dispersants in Canada?	Co-chairs
6	2:45 – 3:00 EST	Discussion Wrap-up / Summary	

CSAS Meeting: Part 5 – Monitoring and Outstanding Science Needs

	Time	**Wednesday March 10, 2021**	
1	11:00 – 11:15 EST	Overview and Objectives for this Session	James McCourt (SL Ross)
2	11:15 – 11:30 EST	Presentation: Review and Insights from Non-Government Research	Mark Brooks (WWF)
3	11:30 – 11:45 EST	Recap on the Discussion about Fate, Behaviour and Effects	Dillon
4	11:45 – 12:00 EST	Presentation: Environmental Monitoring Considerations	
5	12:00 – 12:15 EST	Presentation: Review and Insights from US EPA Monitoring Processes	Robyn Conmy (US EPA)
	12:15 EST	Break (15 mins)	
6	12:30 – 1:30 EST	Discussion and Initial Drafting of Science Advice • Key Question #18: Is there a difference in terms of what we need to monitor when using dispersants versus not? • Key Question #19: How could the information learned through monitoring be used? • Key Question #20: What data would be most beneficial to have in preparedness, in order to monitor and measure potential impacts? • Key Question #21: What are the key metrics for inclusion in each phase of monitoring? • Key Question #22: What are the existing monitoring procedures in Canada for a spill event and what additional monitoring is required to support assessments of effect? • Science Advice: TOR Question #3: What are the key considerations or recommendations for environmental monitoring after dispersant use? • Science Advice: TOR Question #4: What are the priority, outstanding science needs to support the regulatory regime and decision-making for the use of dispersants in Canada?	Co-chairs
7	1:30 – 2:45 EST	Flex Time / Discussion of any Parked Items	
8	2:45 – 3:00 EST	Discussion Wrap-up / Summary	

CSAS Meeting: Part 6 – Science Advice

	Time	Friday March 12, 2021	
1	11:00 – 11:15 EST	Overview and Objectives for this Session • Consensus-based science advice • Recommendations for the Working Paper	Lisa Setterington (DFO)
2	11:15 – 11:30 EST	Review of Additional Items	Co-chairs
3	11:30 – 12:15 EST	Review and Consensus on the Science Advisory Report Bullets	Co-chairs
	12:15 EST	Break (15 mins)	
4	12:30 – 1:30 EST	Continued Discussion	Co-chairs
5	2:00 – 2:30 EST	TOR Question #4: What are the priority, outstanding science needs to support the regulatory regime and decision-making for the use of dispersants in Canada?	
6	2:30 – 3:00 EST	Conclusion and Next Steps	

APPENDIX 3: LIST OF PARTICIPANTS

Name	Organization / Affiliation
Michal Boufadel	New Jersey Institute of Technology
Victoria Broje	Shell Oil USA
Mark Brooks	World Wildlife Fund
Ian Cameron	DFO – Ecosystem Management, National Capital Region
Donovan Case	Atlantic Environmental Response Team Inc.
Eric Chiang	DFO – Ecosystem Management, Pacific Region
Gina Coelho	United States Bureau of Safety and Environmental Enforcement
Robyn Conmy	United States Environmental Protection Agency
David Creber	Dillon Consulting Ltd.
Emily Davis	Dillon Consulting Ltd.
Benjamin de Jourdan	Huntsman Marine Science Center
Heather Dettman	NRCan – CanmetENERGY, Devon
Cory Dubetz	DFO – Science, National Capital Region
Jamie Ferguson	Western Canada Marine Response Corporation
Ben Fieldhouse	ECCC – Science and Technology, National Capital Region
Michal Galus	DFO – Science, National Capital Region
Ryan Greig	DFO – Science, National Capital Region
Charles Greer	National Research Council Canada
Chantal Guenette	Eastern Canada Response Corporation
David Hart	Point Tupper Marine Services
Douglas Helton	United States National Oceanic and Atmospheric Administration
Peter Hodson	Queen's University
Bruce Hollebone	ECCC – Science and Technology, National Capital Region
Lindsay Hounjet	NRCan – CanmetENERGY, Devon
Lisa Isaacman	DFO – Science, National Capital Region
Paula Jackman	ECCC – Science and Technology, Atlantic Region
Greg Janes	Suncor

Name	Organization / Affiliation
Tom King	DFO – Science, Maritimes Region
Ken Lee	DFO – Science, National Capital Region
Stephan LeFloch	CEDRE
Elizabeth Love	CCG – Preparedness and Response, National Capital Region
Elizabeth MacDonald	Canada-Nova Scotia Offshore Petroleum Board
Kyle Matheson	DFO – Science, Newfoundland Region
James McCourt	SL Ross Environmental Research Ltd.
Nathalin Moy	NRCan – Petroleum Resources, National Capital Region
Tim Nedwed	ExxonMobil Upstream Research Company
Patrick O'Hara	ECCC – Canadian Wildlife Services, Pacific Region
Jeff O'Keefe	Canada-Newfoundland and Labrador Offshore Petroleum Board
Gillian Oliver	CCG – Preparedness and Response, Western Region
Uta Passow	Memorial University of Newfoundland
James Porter	ECCC – Environmental Protection, National Capital Region
Brian Robinson	DFO – Science, Maritimes Region
Boumy Sayavong	CCG - Preparedness and Response, National Capital Region
Paul Schuler	Oil Spill Response Limited
Lisa Setterington	DFO – Science, National Capital Region
Lana Shaya	DFO – Science, National Capital Region
Mike Stoneman	DFO – Science, National Capital Region
Shannon Stuyt	DFO – Science, National Capital Region
Robert Totten	Atlantic Environmental Response Team
Blain Trainor	CCG – Preparedness and Response, National Capital Region
Alex Tuen	DFO – Science, National Capital Region
Aisha Uduman	DFO – Ecosystem Management, Pacific Region
Rob Willis	Dillon Consulting Ltd.
Helen Zhang	Memorial University of Newfoundland