Net Environmental Benefit Analysis in Support of the Shelburne Basin Venture Exploration Drilling Project

Nova Scotia, Canada

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List of Abbreviations, Symbols and Acronyms

bbl	barrel
bpd	barrels per day
CERA	Consensus Ecological Risk Assessment
CROSERF	Chemical Response to Oil Spills: Ecological Effects Research Forum
DMP2	Dispersant Mission Planner 2
DO	Dissolved oxygen
DOR	Dispersant to oil ratio
DOSS	Dioctyl Sodium Sulfosuccinate
DWH	Deepwater Horizon spill (aka Macondo spill)
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
ERA	Ecological Risk Assessment
ERD	Emergency Response Division
g	Gram
gal	Gallon
gpd	Gallon(s) per day
HAZMAT	Hazardous Materials
IBA	Important Bird Area
ISB	*In-situ* Burning
km	Kilometre
L	Local
m	Metre
NEBA	Net Environmental Benefit Analysis
NEDRA	Net Environmental Damage & Response Assessment
NOAA	National Oceanic & Atmospheric Administration
NRC	National Resource Council
ppb	Part per billion, as referring to concentration
ppm	Part per million, as referring to concentration
R	Regional
RAA	Regional Assessment Area
RAR	Resources at Risk
SIMAP™	Spill Impact Model Application Package, a 3D trajectory and fate model
SMART	Special Monitoring of Applied Response Technologies
TPH	Total Petroleum Hydrocarbons
µm	Micrometer or microns
USCG	United States Coast Guard
VC	Valued Components

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Executive Summary

This Net Environmental Benefit Analysis (NEBA) was conducted in support of Shell Canada Limited's (Shell) oil spill response planning for the Shelburne Basin Venture Exploration Drilling Project (the Project). The analysis is based largely on information provided in several reports prepared in support of the Project. These supplementary sources include:

- Shelburne Basin Venture Exploration Drilling Project: Environmental Impact Statement (EIS; Stantec 2014a) and associated Appendices (Stantec 2014b)
- The preliminary findings of the Shelburne Basin Venture Seabed Survey (Stantec 2014c)
- Trajectory Modelling in Support of the Shelburne Basin Exploration Drilling Program: Model Description, Approach and Summary of Results (Horn and French McCay 2014a)
- Trajectory Modelling in Support of the Shelburne Basin Exploration D rilling Program: Analysis of Subsurface and Surface Dispersant Application Modelling (Horn and French McCay 2014b)
- Shelburne Basin Venture Exploration Drilling Project: Oil Spill Response Plan (OSRP) (Shell Canada Limited 2015a)
- Shelburne Basin Venture Exploration Drilling Project: Venture Dispersant Preparedness and Operations Plan (Shell Canada Limited 2015b)

These reports serve as the basis for this NEBA and are referenced where relevant, but the information has not been reiterated here to avoid duplication. As such, the reader is urged to refer to these reports for further background and operational information. This report is intended to support response efforts in association with a subsea blowout scenario in advance of successfully capping the well. This report does not examine alternative potential release scenarios (i.e., from other sources, such as surface releases from the rig platform or from support vessels or other drilling products. Additionally, this NEBA focuses on the *ecological* aspect of the associated response options. While it is understood that a large oil spill, such as that assessed as part of the NEBA, will have socio- economic, and cultural impacts, such impacts have been considered within the ecologica l context (i .e., impacts to the resource of c oncern that are of socio -economic and cultural importance). Detailed socio -economic and cultural impact assessments are beyond the scope of this NEBA.

In oil spill response, o nce human health and safety are addressed, the over-riding concern is containment and mitigation in order to minimize environmental impacts. In the majority of spill scenarios, no single response option is likely to be completely effective. Therefore, the best approach to minimize environmental impacts is to have multiple response options available. The objective of a NEBA is to consider all available response options and identify those techniques that will provide for the best opportunities to minimize environmental consequences.

When a NEBA app roach is used, the analysis is based on the use of a relative, or comparative, risk framework. The basic premise of the analysis is that appropriate decisions are contingent upon determining how all available response options might be used to minimize dama ge and encourage recovery of the environmental and social-economic systems. This analysis is based on consideration of the benefits and limitations of each of the available response options . In addition, it provides an assessment of the relative risk to each resource of concern from each response option , using "natural attenuation" (i.e., no human intervention) as the baseline for comparison. This allows a comparison of how each response option affects resources of concern relative to the other available options. All

available response options have both limitations and potential benefits. A recent publication by the International Petroleum Indu stry Environmental Conservation Association (IPIECA) describes the four elements associated with the NEBA process (IPIECA 2013, 2015c):

1. **Collect information on the physical and biological environmental conditions as well as the human use of the area of interest.**
    - *This step was completed via preparation of the Project EIS and preliminary baseline studies (Stantec 2014a,b,c) which are precursors to this NEBA document.*
2. **Review previous spill case histories and experimental results which are relevant to the area and to the available response methods.**
    - *Past scientific studies and learnings from previous offshore spill incidents were reviewed and, as applicable information has been incorporated into this report.*
3. **On the basis of previous experience and professional judgement , predict the likely environmental outcomes if the proposed response is used, and compare to if the area is left for natural attenuation.**
    - *Based largely on professional judgment as well as experience and learnings from other offshore spill incidents.*
4. **Compare and weigh the advantages and disadvantages of the available response options against the outcome of using natural attenuation.**
    - *This is a semi -qualitative process and relies heavily on the professional judgement and experience of the authors, as well as input from regulator s and federal/provincial resource managers in the Nova Scotia region gathered through engagement and review.*

This NEBA was conducted using a risk matrix which supports the evaluation of the interaction of potential response options and ecological resources. This conceptual model is a depiction of how the various ecological resources (summarized by habitat) might respond when exposed to a response option. Once the risk matrix was completed and the resource and trajectory data evaluated, the study team used a "risk ranking matrix" in order to assign a level of concern to each box in the risk matrix. All subsequent rankings are relative to the baseline (natural attenuation of the oil spill) , i.e., are conditions better or worse for each resource when using the response option. The results of this analysis were then used to develop recommendations regarding the available response options.

The NEBA analysis concluded that successful implementation of any of the available response options will result in a reduction in consequences to the considered resources of concern , when compar ed to the baseline condition of no active intervention . As a result, all available response options should be considered when developing the oil spill response plan for the Project.

However, the response options do vary in their potential effectiveness , based on operational or logistical considerations. Based on the NEBA analysis, subsea dispersant injection is considered the most operationally feasible spill response option available in association with the Project , and also offers the most environmental benefit. As a result, subsea dispersant injection is recommended as a primary response option for the reasons provided below. The anticipated operational effectiveness of each option is summarized in the order of least to most environmentally beneficial based on the results of the NEBA analysis:

- **On-water In-situ Burning (ISB)** – the majority of environmental conditions in the North Atlantic do not allow for successful implement ation of this response option. Successful implementation requires effectively containing the oil (in fire boom) long enough to safely implement a burn, which is severely restricted by seasonal day length, year -round weather conditions, difficulty of corralling a thin sheen of oil in a turbulent offshore environment and logistic al constraints. Although it may result in minor improvements over natural attenuation, it will not offer any substantial ecological benefits , but may provide localized benefits in areas where it is successfully deployed.
- **On-water mechanical recovery** – while this response option is constrained by factors that are similar to those for ISB, on -water mechanical recovery resources are generally easier to obtain and deploy in larger numbers than those for ISB . Although this option can be effective for smaller, con fined spills, the estimated recovery for large volume discharge scenarios (with prevailing sea states in the North Atlantic) is considered too low to provide any material regional ecological benefit.
- **Shoreline protection and recovery** – The trajectory spill modelling completed for the Project indicates there is a low probability of shoreline contact resulting from an offshore spill incident. However, in the rare cases where shoreline contact occurs, this response option is essential. Shoreline protection and recovery can result in improvements over the natural attenuation and an effective response plan for protection of the ecological resources on Sable Island National Park Reserve (and other sensitive shorelines in the Project area) is a very important consideration.
- **Aerial dispersant application** – This response option was shown to be effective in re ducing surface oil in treated areas . Trajectory modelling indicates that with the application of aerial dispersants the modelled oil (i.e. , light oil) can be easily dispersed near the source. It will likely spread into thin layers as it remains on the surface of the water. Consequently, dispersant effectiveness will vary depending on the environmental conditions that affect both the physical properties of the oil and the operations needed to apply the dispersant . Hydrocarbon concentrations in the upper 10 to 20 m of the water column would increase in treated areas, but concentrations would decline within hours, and would not pose a long-term risk to the ecosystem given rapid dispersion, biodegradation and low toxicity of the dispersants . This response option is subject to weather and logistic limitation. While not as significant as on -water recovery and ISB, these limitations can affect deplo yment capabilities and potentially effectiveness. This option could be very valuable early in the release scenario while other response options, such as subsea dispersant injection equipment, is enroute.
- **Subsea dispersant injection (SSDI)** – This response o ption leads to the greatest net environmental benefit, and is recommended as a primary response option. This option provides the most marked improvement in risk scores for resources on the water surface and on the shoreline, with only a minor increase in the level of concern for invertebrates and plankton in the deep water column (based on an increase in the area of concern due to an expanded dispersed oil plume but still rapid recovery) . It has the potential to substantially reduce floating oil (potentially near zero, once implemented), as well as reduce dispersed oil concentrations in the sensitive upper water column (surface to 100 m). Once in place, this response option is less sensitive to weather limitations than other available response options, and is the only option with the potential to operate 24 hours, seven days a week. It reduces the need for surface

recovery, in-situ burning, and surface dispersant operations, thereby reduc ing the potential for oil exposure, and accidents or incidents during these operations. In addition to these ecological considerations, the importance of maintaining a safe Source Control environment for response workers operating above the oil release site is paramount to an effective emergency response. Use of SSDI can substantially reduce surface volatile organic compounds (VOCs) and reduce the likelihood of exceeding Lower Explosive Limits , impro ving well intervention activities and capping stack deployment capabilities. Consequently, it is an important tool that h elps to safely sustain well-capping and source containment operations during a blowout situation.

It is important to recognize that during a spill, the best response almost always results when a combination of response techniques are used together to minim ize ecological damage and promote the fastest overall recovery of the ecosystem. So while the response options are considered individually in this document, it is understood that multiple response options will likely be used during an actual spill.

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1 Net Environmental Benefit Analysis

1.1 Background

WHAT IS NEBA?

The objective of a NEBA is to consider all available response options for an oil spill and select those techniques that will provide the best opportunities to minimize consequences for the environment (Aurand *et al.*, 2000; IPIECA 2000, 2015c; ASTM 2014).

This section of the report provides an overview of the analytical approach used to prepare this Net Environmental Benefit Analysis (NEBA) in support of oil spill response planning for Shell Canada Limited's (Shell) Shelburne Basin Venture Exploration Drilling Project (the Project). The analysis is based largely on information provided in several existing reports prepared in support of the Project. They are:

- Shelburne Basin Venture Exploration Drilling Project: Environmental Impact Statement (EIS) (Stantec 2014a) and associated Appendices (Stantec 2014b)
- The preliminary findings of the Shelburne Basin Venture Seabed Survey (Stantec 2014c)
- Trajectory Modelling in Support of the Shelburne Basin Exploration Drilling Program: Model Description, Approach and Summary of Results (Horn and French McCay 2014a)
- Trajectory Modelling in Support of the Shelburne Basin Exploration Drilling Program: Analysis of Subsurface and Surface Dispersant Application (Horn and French McCay 2014b), and
- Shelburne Basin Venture Exploration Drilling Project: Oil Spill Response Plan (OSRP) (Shell Canada Limited 2015a).
- Shelburne Basin Venture Exploration Drilling Project: Venture Dispersant Preparedness and Operations Plan (Shell Canada Limited 2015b).

These existing reports serve as the basis for this NEBA and are referenced where relevant, but the information has not been reiterated here to avoid duplication. As such, the reader is urged to refer to these reports for further background and operational information. NEBA is a process generally coordinated between government and industry to identify the best available response options in the event of a spill in order to minimize the potential impacts on people and the environment (IPIECA Scan and Glance, 2013).

In oil spill response, once human health and safety are provided for, the over-riding concern is containment and mitigation in order to minimize environmental impacts. In the majority of spill scenarios, no single response option is likely to be completely effective. Therefore, the best approach to minimize environmental impacts is to have multiple response options available. A risk-based approach is implicit in all response planning; however, the required level of detail in determining and documenting the approach depends upon the type of incident and the circumstances. A NEBA provides response planners with a well-documented, transparent and easily understandable product to aid in response tactic decision making through provision of the rationale and justification for the selection of different

response options during an incident. In general, NEBA becomes a more valuable planning tool as the potential incident threat, the value of the considered ecological component, and the diversity/complexity of available response options increase.

The NEBA concept has been employed by a number of countries for several decades (Baker 1995 and IPIECA 2000). While this document uses the term "NEBA" there is other terminology which has a similar, but not identical meaning. In some situations the terms Environmental Consequence Analysis or Relative Risk Assessment may be preferred as alternative terms for NEBA. In other cases the focus may be slightly different; for example, in the United States the US Environmental Protection Agency (EPA) and the US Coast Guard (USCG) may use the term Ecological Risk Assessment (ERA) or Consensus ERA (CERA) (Aurand *et al*., 2000). A recent NEBA publication by IPIECA (2015c) provides a more detailed discussion on the application of NEBA for response strategy development.

In the United States, the NEBA process is used in oil spill preparedness planning and response. Before a spill, the formal NEBA process is conducted during the planning phase at the Area and Regional Response Team levels with input from state and Federal participants to determine the benefits and limitations from using each response technology within their individual areas of responsibility. In most offshore regions of the US, this was accomplished in the form of the Consensus-Based Ecological Risk Assessments (CERA) process used by the USCG (Aurand *et al*., 2000), and supported by NOAA, EPA, other Federal and state agencies, and academia. More than twenty workshops were held in various locations around the continental US, Caribbean, and Alaska from 1995 to 2011 to compare the benefits and risks of various response options when considering resource trade-off decisions. All of the workshops resulted in final publications (available from USCG) that were delivered to the Area Committees and Regional Response Teams to assist with response planning. One example of how this CERA/NEBA process was used to inform dispersant use decision-making is summarized in several papers authored by regulators in the state of California (Addassi and Faurot-Daniels, 2005; Addassi *et al.,* 2005). The applicability of the CERA/NEBA process as a tool for facilitating dispersant decision-making during spill response and planning was also evaluated by NOAA (Mearns and Evans, 2008). Ultimately, the USCG and EPA used their ERAs to help establish dispersant pre-approval zones across the U.S.

Another approach, the Net Environmental Damage and Response Assessment (NEDRA) has been developed in Norway (SINTEF 2012). NEDRA involves valuing ecological services or other properties, assessing adverse impacts, and evaluating restoration options. No matter what terminology is assigned to the process, the aim is the same: to reduce the overall impact (ecological, economics, etc.) resulting from an oil spill.

All of these approaches typically focus on only a portion of the issues which must be resolved in order to make a decision associated with a proposed response option. Figure 1 is a representation of all of the potential factors which may ultimately influence a decision by regulators on a proposed response plan. Some of these factors, such as technological feasibility, regulatory and legal requirements, and political issues (e.g., multi-national boundaries), may influence what response options are available for consideration in a NEBA, but may not be considered as part of the risk analysis. Exactly where the line is drawn for inclusion of social, economic, and ecological issues in a NEBA will differ between study locations, other concurrent planning activities and consultations. While it is understood that a large oil spill in the Shelburne Basin may have social, economic, and cultural impacts, such impacts have been

considered primarily within the ecological context (i .e., impacts to the resources of concern that are of social, economic and cultural importance). Detailed social, cultural and economic impact assessments are beyond the scope of this NEBA. For this reason, this NEBA was designed specifically to assess the level of concern over *ecological* consequences of various response options and to evaluate response options. It is not intended to estimate potential damages of a spill, but rather to identify what response options (when compared to Natural Attenuation) can minimize oiling of sensitive resources and promote rapid recovery of the ecosystem.

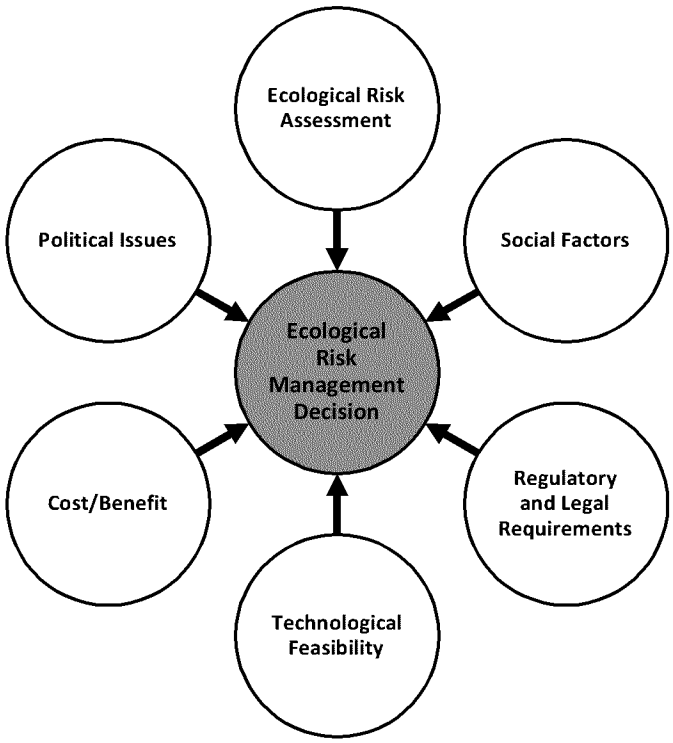

Figure 1. Potential factors in a risk management decisions associated with oil spill response

1.2 Objective

The objective of this NEBA is to evaluate and compare oil spill response options which are being considered in association with an oil spill response plan to support the Project. In addition, the NEBA is intended to support spill response efforts, in the unlikely event of a spill incident, and provide a basis for acquiring approval for the use of Spill Treating Agents (i.e. , dispersants) in association with proposed legislation (i.e., Bill C22) on the matter.

The emphasis of this NEBA is on a structured qualitative analysis to identify response options which offer a net environmental improvement over the natural attenuation baseline. It is not intended to be a quantitative analysis. The purpose of the analysis is to help inform decisions. In summary, NEBA is a holistic approach that should:

1. Consider potentially impacted resources of concern.
2. Consider how well they can be protected with the available re sponse techniques under the conditions prevailing at the time of a spill.
3. Seek to identify the response option(s) that provide the best overall outcome to a spill (Stevens and Aurand 2007).

1.3 NEBA Process and Development of a Risk Matrix

When a NEBA approach is used, the analysis should be based on the use of a relative, or comparative, risk framework. The basic premise of the analysis is that appropriate decisions are contingent upon determining how all available response options might be used to minimize impact and encourage recovery to the environmental and socio-economic systems. This should be based on the risk posed by each of the available response options to the identified resources of concern in comparison to all of the other available response options using "natural attenuation " (i.e., no human intervention) as the baseline for comparison. All response options have both limitations and potential benefits. The goal is to identify both, and then realistically evaluate the ecological trade-offs inherent in the use of each response option relative to other options and to the baseline (i.e., natural attenuation). In order to accomplish that goal, IPIECA (2013) identifies four elements associated with the NEBA process:

1. **Collect infor mation on the physical and biological environmental conditions as well as the human use of the area of interest.**
    - *This step was completed via preparation of an EIS and preliminary baseline studies (Stantec 2014a,b,c) which are precursors to this NEBA document.*
2. **Review previous spill case histories and experimental results which are relevant to the area and to the available response methods.**
    - *Best professional judgment by the team of authors was used to cite past scientific studies and learnings from previous offshore spill incidents, as applicable.*
3. **On the basis of previous experience, predict the likely environmental outcomes if the proposed response is used, and compare to if the area is left for natural attenuation.**
    - *Based largely on learnings from previous offshore spill incidents.*
4. **Compare and weigh the advantages and disadvantages of the available response options against the outcome of using natural attenuation.**
    - *This is a semi -qualitative process, at best, and relies heavily on the best professional judgement of the authors, as well as input from regulatory experts in the Nova Scotia region gathered through engagement and review.*

NEBA generally focuses on comparisons between and within the identified resources of concern when various response options are weighted, such as:

- Does the socioeconomic benefit of a particular spill response method outweigh direct ecological impacts?
- Does the benefit to shoreline organisms , seabirds and marine mammals from using oil dispersants at sea outweigh the potential impact to fishery resources from exposure to dispersed oil?
- Does a clean-up method benefit one resource but impact another?

- Do different clean-up methods achieve the same outcome, but at different levels of efficiency, varying levels of impact, or over different spatial and temporal frames?

As summarized by Stevens and Aurand (2007), the NEBA approach can also help to identify potential trade-offs that may arise in the protection of different resources. NEBA is most effective when conducted during the planning phase when potential trade-offs between environmental, social, economic or aesthetic concerns can be discussed and resolved as part of the planning process. Further, when NEBA is conducted in the planning phase, it can help inform oil spill response plans with respect to stockpiling of appropriate equipment, and can help set expectations for response option effectiveness.

Having a defined, understandable methodology for conducting the analysis is critical. It provides the analytical, scientific, and documentary support for relative risk comparisons between effects on the identified resources of concern from various response options. A widely accepted approach to conducting this required comparative analysis is provided in the USCG guidelines for developing CERAs (Aurand *et al.*, 2000). This approach utilizes a **risk matrix** and a **risk ranking matrix**.

The completed risk matrix is the key to the NEBA analysis: it allows comparisons between response options as well as across habitats and resource groups. The completed risk matrix provides an overview of the level of concern (i.e., risk) potentially imposed on the various resources of concern from the available response options. The risk matrix designed for this particular NEBA is shown in Figure 2. The resources of concern identified in Figure 2 and used in the NEBA analysis were derived from consideration of the baseline environmental information described in the EIS (Stantec 2014a,b) for the Regional Assessment Area (RAA). See section 5 of the EIS for further details.

In order to complete the risk matrix analysis, a risk ranking matrix is developed and used to assign levels of concern to each resource of concern (row) from the individually considered response options (column) in the risk matrix. Figure 3 presents a simplified example of a risk ranking matrix. Each axis represents a parameter used to describe risk. Here the x-axis evaluates "population recovery" and ranges from "reversible" to "irreversible," while the y-axis evaluates "magnitude" and ranges from "minor" to "severe". Each cell is assigned an alphanumeric value to represent relative impact. Thus, in this simplified example, a "1A" represents an irreversible and severe effect, while a "2B" represents a reversible and minor effect. While a simple 2 by 2 matrix is discussed here for illustration of the concept, actual NEBA analysis requires greater resolution. As a result, a NEBA typically employs a 4 by 4 or a 5 by 5 matrix for sufficient resolution and complexity (i.e., it is not overly difficult to complete for a number of response options and resources of concern).

				Response Options						
				Ref. Habitat*	Natural Attenuation	On-water Mechanical Recovery	On-water In-situ Burning	Surface Dispersants	Subsea Dispersants	Shoreline Protection & Recovery
Resources of Concern	Shoreline	Southern Tip of Nova Scotia	Mammals	R						
			Birds	R						
			Fish	R						
			Invertebrates	R						
			Plankton	R						
			Vegetation	R						
		Sable Island	Mammals	R						
			Birds	R						
			Fish	R						
			Invertebrates	R						
			Plankton	R						
			Vegetation	R						
		Recreational Fisheries		R						
		Cultural and Subsistence		R						
	Shelf	Surface Layer	Mammals	R						
			Birds	R						
			Fish (larvae/eggs)	R						
			Sea Turtle	R						
			Invertebrates	R						
			Plankton	R						
		Water Column (shallow; < 100m)	Mammals	R						
			Sea Turtles	R						
			Birds	R						
			Fish	R						
			Invertebrates	R						
			Plankton	R						
		Water Column (deep; > 100m)	Mammals	R						
			Fish	R						
			Invertebrates	R						
			Plankton	R						
		Benthos	Fish	R						
			Corals & Sponges	L						
			Other Invertebrates	R						
		Commercial Fisheries		R						
		Cultural and Subsistence		R						

POPULATION and SPATIAL DISTRIBUTION

From a biological perspective, the term "population" means different things to different people. Within this NEBA, the term "population" is defined as a collection of species within a Resource Category within a defined Area of a defined Habitat within the study area of the EIS. For example, mammals that use deep waters (>100m) of the Shelf are assessed as one population in this analysis (circled to the left).

Table 3, which appears later in this report, provides a list of representative species within each population, and also identifies specific "species at risk" (from the EIS) within a given population. More information is provided in Section 2.2.

While it is acknowledged that many species have patchy distribution, a uniform distribution of the population was assumed within an area of the habitat when assessing potential effects on the population from each response option. It is a limitation in the NEBA process.

*R – Regional is defined as the entire Nova Scotia region, L – Local was defined as "near field" of the well head (~10 km)

Figure 2. NEBA analysis risk matrix

Resources of Concern				Response Options						
				Ref. Habitat*	Natural Attenuation	On-water Mechanical Recovery	On-water In-situ Burning	Surface Dispersants	Subsea Dispersants	Shoreline Protection & Recovery
	Slope	Surface Layer	Mammals	R						
			Birds	R						
			Fish (larvae/eggs)	R						
			Sea Turtle	R						
			Invertebrates	R						
			Plankton	R						
		Water Column (shallow; < 100m)	Mammals	R						
			Sea Turtles	R						
			Birds	R						
			Fish	R						
			Invertebrates	R						
			Plankton	R						
		Water Column (deep; > 100m)	Mammals	R						
			Fish	R						
			Invertebrates	R						
			Plankton	R						
		Benthos	Fish	R						
			Corals & Sponges	L						
			Other Invertebrates	R						
		Commercial Fisheries		R						
		Cultural and Subsistence		R						
	Special Areas	Gully Marine Protected Area		L						
		Roseway Basin		L						

*R - Regional, L – Local

Figure 2. NEBA analysis risk matrix *(cont.)*

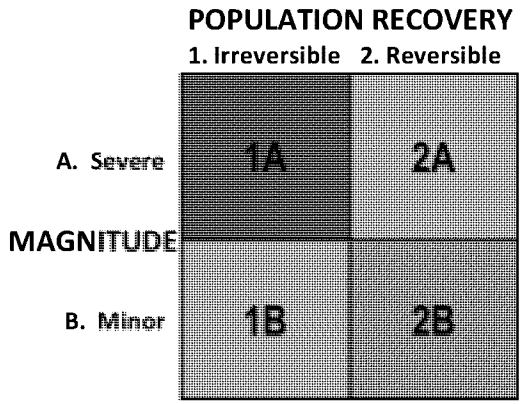

Figure 3. Basic risk ranking matrix

In the NEBA, r esponse options are considered as a source of potential ecosystem stress relative to stresses caused by the spilled oil. The mechanisms that cause this stress are not always the same, and may differ in magnitude between options. Seven "hazards" determine potential exposure pathways that link the stressors (including natural attenuation) to the resources of concern. The seven hazards are:

1. Air pollution
2. Aquatic toxicity
3. Physical trauma (i.e., mechanical impact from people, boats, etc.)
4. Oiling or smothering
5. Thermal (i.e., heat exposure from ISB)
6. Oil-contaminated waste materials transfer and disposal
7. Indirect (refers to a secondary effect such as ingestion of contaminated food)

For example, on -water recovery may affect mammals through physical injury or disturbance. On-water recovery is the **stressor**, mammals are the **resource of concern**, and physical injury or disturbance is the **hazard** by which the mammals are affected (i.e., a dolphin is struck by a propeller on a workboat handling skimming operations) . Consequently, if a NEBA classifies mammals as a resource of concern and on -water recovery is a possible resource option, planners must understand the types, relative abundance and behavior patterns of the mammals in the study area to gauge to what degree the response option may cause physical injury or disturbance relative to that already caused by the oil . It is important to understand that the assessment represents changes from the natural attenuation of an oil spill. For example, the same mammals discussed above could potentially benefit from on-water recovery as a result of reduction in potential for oiling or smothering. The alpha-numerical score attributed in the risk matrix is calculated using the risk ranking matrix and is based on any associated benefit as well as the degree of impact posed by a hazard to the individual resource of concern for a particular response option. When the resource of concern cannot be linked to a response option through a hazard then there is no risk.

As part of the risk ranking process, multiple reference "populations" are defined in order to estimate the percent of a population affected (see text box in Figure 2 for more information). The EIS prepared for the Project served as the basis for the populations that were assessed in this NEBA . Details on the specific risk matrix and risk ranking matrix that were developed for this study are given in Section 3.2 of this report.

In brief, the steps for this overall process are as follows:

- Prepare oil spill scenario (or scenarios) for analysis
- Identify resources of concern and associated toxicity/exposure thresholds of concern
- Prepare a conceptual matrix (response options versus resources of concern) to guide the subsequent analysis
- Characterize resource impact if no response is implemented (e.g., natural attenuation baseline)
- Characterize resource impact from individual response options by relating oil exposure to levels of ecological concern.
- Compare the results to the natural attenuation baseline
- Identify options which improve over baseline
- Identify uncertainties and limitations
- Determine implications and consequences for response planning
- Communicate the results and rationale.

2 Spill Scenarios and Baseline Information

2.1 Geographic Area of Interest and Spill Scenarios

The geographic area of interest for the NEBA analysis includes the Southwest Scotian Slope, Sable Island and the southern tip of Nova Scotia (see Figure 4). The primary reference area used is the Regional Assessment Area (RAA) to maintain consistency wit h the EIS (Stantec 2014a).

A key feature of this area is defined by the Scotian Shelf/Slope break, which influences the distribution of biological resources as well as the regional hydrodynamic regime. The seaward extent of the RAA is restricted to the 200 nautical mile limit of Canada's Exclusive Economic Zone and includes offshore marine waters of the Scotian Shelf and Slope (see purple outline in Figure 4).

The scenarios considered in this report are based on information provided in the EIS and a series of oil spill simulation studies conducted by RPS ASA (Horn and French McCay, 2014a and 2014b). A brief summary of the salient factors is provided below, including references to specific portions of these documents, where appropriate. These references should be consulted if additional technical detail is desired. Note that the full dispersant modelling report is available upon request. Most of the analytical discussions in this report are based on the geographic area referred to in the EIS RAA. The conclusions outlined in this assessment are based on an analysis of deep water subsea well blowo uts (with and without dispersant application) at two exploratory drilling sites (Site 1 and Site 2) located approximately 250 km offshore Nova Scotia (Figure 5). The blowout volumes used were based on calculated Worst Case Credible Discharge for each site.

SELECTING A SCENARIO

The selection of a spill scenario (e.g., oil type, oil volume, location, season and weather) is frequently the topic of debate, with many perspectives on what the "best" scenario is when planning for oil spills. Since the purpose of this NEBA was to evalua te the *ecological* consequences of various response techniques, a summer season was selected with a Worst Case Credible Discharge volume. Since the summer weather conditions support all response options, this scenario allows for an even comparison of each o ption under a worst case release. The type of oil chosen for the trajectory model was Federated Crude oil, which is considered a representative product with similar chemical and physical properties as that expected in the target reservoir.

The authors re cognize that in winter months, some "at sea" response options (e.g., mechanical recovery and ISB) may not be feasible with sea states typically above 2 m. However, the reader is reminded that these higher sea states in winter months (or in storm events) wi ll promote more natural dispersion, which will achieve the same objective of removing oil from the sea surface and preventing oil from approaching near shore resources.

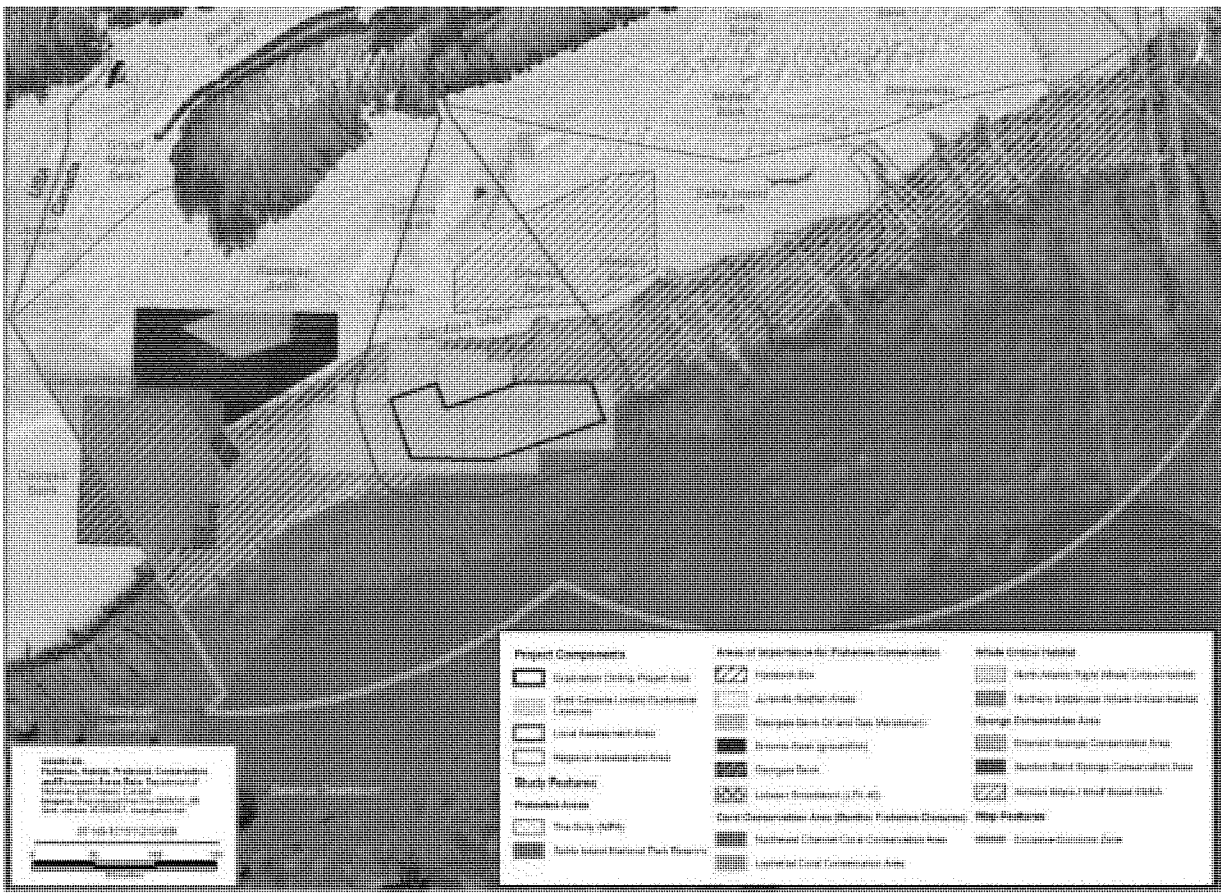

Figure 4. Spatial Boundaries for Environmental Assessment (from Stantec 2014a - Figure 3.1).

RPS ASA was tasked with preparing 3D oil spill trajectory and fate modelling in support of the EIS and also to characterize the expected variation in oil fate and trajectory between unmitigated cases (i.e., no response actions taken) and mitigated (i.e., application of surface dispersant or subsea dispersant). The basic parameters of these efforts are outlined below and the results are summarized in Section 2.4.

As presented by Horn and French McCay (2014a), in the first phase of the study, continuous unmitigated subsurface blowout scenarios were developed at the two sites, which were chosen to consider variations in water depths as well as proximi ty to sensitive marine features (Table 1). Federated Crude Oil was chosen as a representative product for the modelling given similar chemical and physical properties to that expected for the oil in the target reservoir. Use of this oil type was also considered an additional conservative measure based on the low viscosity and higher aromatic content of this product. Modelled release volumes and rates varied with 747,000 bbl (24,900 bpd) blowouts at Site 1 and 1,474,500 bbl (49,150 bpd) blowouts at Site 2 (Table 1). These modelled parameters were chosen based on estimated well parameters for the various depths chosen and considered to be representative of the wells that would be drilled for the Project. Model and release duration for all modelled scenarios was 30 days (considered worst case scenario duration) , with a continuous release of Federated Crude oil. The near-field blowout plume model OILMAPDeep™ characterized the subsurface blowout in 3D (i.e., on the water surface and throughout the water column).

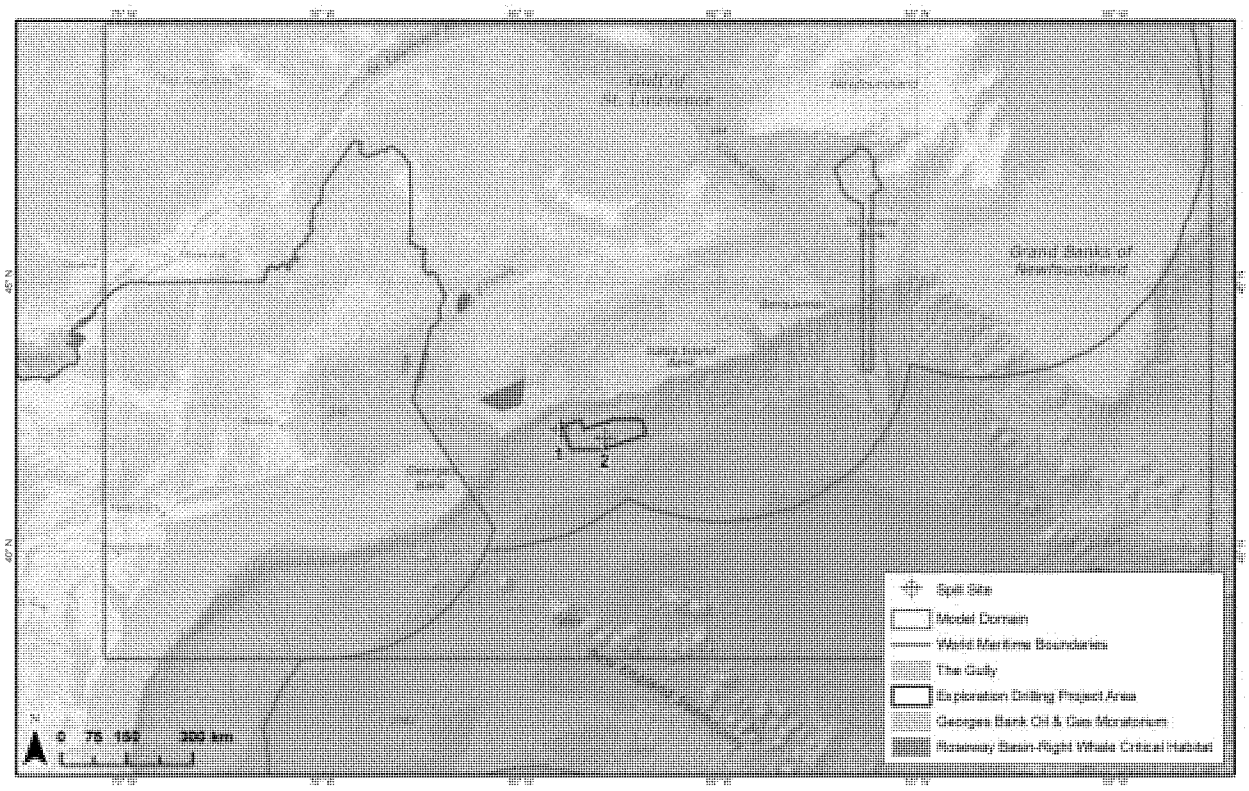

Figure 5. Location of Sites 1 and 2 used in oil spill trajectory modelling in relation to other study area features (from Horn and French McCay 2014b).

In the second phase of the study, the far -field trajectory and fate of four representative dispersant-mediated blowouts were investigated using the SIMAP TM (Spill Impact Model Application Package) model. This model estimated the 3D distribution of the oil in the marine environment from the release, providing individual trajectories, mass balance information, and predicted oil thicknesses and concentrations on and in the water (Table 2). The modelling involved two simulations: subsea dispersant injection at each site from the beginning of the release (to conservatively determine maximum possible concentration of oil in the water column) and a 4-day aerial application of dispersant to the initial unmitigated surface slick until subsea dispersants could be applied (Table 2) (Horn and French McCay 2014b). Scenarios identified for this modelling also included the 95th percentile scenarios (representing maximum surface oiling) using summer season environmental conditions (April through September) for Sites 1 and 2 from the trajectory modelling report (Horn and French McCay 2014a). Summer conditions were identified as candidates for this study, as warmer and more quiescent summer conditions resulted in larger surface oil by both mass and area covered, as compared to winter conditions and previous modelling. These 95 th percentile sc enarios are representative deterministic cases that were identified from stochastic analyses (480 runs per site ; 240 runs per summer/winter season) as having some of the largest areas of surface ocean affected (95th percentile) from spilled oil.

Table 1. Unmitigated Modelled Spill Scenarios (after Horn and French McCay 2014a; modified from Appendix G in Stantec 2014a)

Spill Location	Depth of release	Model Duration	Release Duration	Number of Model Runs	Released Product	Release Type	Oil Release Volume
Site 1 (42.3°N, 64.0°W)	1700 m	30 days	30 days	40 per month x 12 months	Federated Crude Oil	Unmitigated Blowout	747,000 bbl (24,900 bpd)
Site 2 (42.15°N, 62.9°W)	2500 m	30 days	30 days	40 per month x 12 months	Federated Crude Oil	Unmitigated Blowout	1,474,500 bbl (49,150 bpd)

Table 2. Dispersant Mitigated Modelled Spill Scenarios (after Horn and French McCay 2014b)

Spill Location	Depth of release	Release Date & Time	Release Duration & Model Duration	Scenario Type	Released Product	Oil Release Volume	Dispersant to Oil Ratio (DOR)	Dispersant Release Volume
Site 1 (42.3°N, 64.0°W)	1700 m	July 14, 2009 @ 1908	30 days 30 days	Subsea Dispersant Mitigated Blowout	Federated Crude Oil	747,000 bbl (24,900 bpd)	1:60 (effective 1:75)	522,900 gal (17,430 gpd)
Site 2 (42.15°N, 62.9°W)	2500 m	August 7, 2009 @ 0659	30 days 30 days	Subsea Dispersant Mitigated Blowout	Federated Crude Oil	1,474,500 bbl (49,150 bpd)	1:80 (effective 1:100)	774,120 gal (25,804 gpd)
Site 1 (42.3°N, 64.0°W)	1700 m	July 14, 2009 @ 1908	4 days 4 days	Surface Dispersant Mitigated Blowout	Federated Crude Oil	9,960 bbl (24,900 bpd)	1:20	49,012 gal Variable Rate
Site 2 (42.15°N, 62.9°W)	2500 m	August 7, 2009@ 0659	4 days 4 days	Surface Dispersant Mitigated Blowout	Federated Crude Oil	196,600 bbl (49,150 bpd)	1:20	49,012 gal Variable Rate

2.2 Resources of Concern

Detailed information on the biological resources present in the study area is provided in Section 5 (Existing Environment) of the EIS (Stantec 2014a). Based on this information from the EIS and the results of the transport and fate modelling, a resources of concern summary list was identified for the analysis (see Table 3 on the following pages). The species-specific information (especially for Valued Components -VC) in the EIS was taken into account in selecting and characterizing the ecological communities

identified as resources of concern. The analysis in this report is based on the generalized ecological communities and/or habitat types present in that affected area, except in instances w here one key species or specific community is key to evaluating the level of concern. The resources of concern identified for the analysis in this report include the following:

- Marine Mammals
- Birds
- Fish
- Invertebrates
- Plankton
- Vegetation
- Sea Turtles
- Corals & Sponges
- Cultural & Subsistence
- Commercial Fisheries

The resources of concern table is constructed to emphasize the difference between habitats offshore, on the **slope**, on the **shelf** and on the **shoreline**. The table also includes the resource categories "Cultural and Subsistence" (to denote Aboriginal Use) and "Commercial Fisheries". These resources of concern were chosen for the NEBA analysis based on the high level of importance attached to them, as identified in the EIS. These particular Resources of Concern are depicted crossing both the Habitat and Resource Category columns in the table. This was purposely done to symbolize their assignment across all resource categories rather tha n repeating it within each of the Habitat and Resource Category entries. Special Areas such as the Gully and Roseway Basin were also added because of their importance in this Project Area and to consider localized vs. regionalized spatial considerations in regards to the various response options.

Table 3. Resources of Concern Developed for the Nova Scotia NEBA (based on the EIS)

AREA	HABITAT	HABITAT DESCRIPTION	RESOURCE CATEGORY	REPRESENTATIVE SPECIES or SPECIFIC CONCERNS
Shoreline	Southern tip of Nova Scotia Intertidal	Marine intertidal zone is defined as the area of the foreshore and seabed that is exposed to the air at low tide and submerged at high tide.	Marine Mammals	Grey and Harbour Seals
			Birds	IBAs: South Shore (Barrington Bay Sector), South Shore (Roseway to Baccaro Sector), South Shore (Port Joli Sector), South Shore (East Queens Co. Sector), The Brothers, Bon Portage Island, Eastern Cape Sable Island, Grassy Complex Area Species at Risk: Piping Plover, Roseate Tern, Harlequin Duck, Red Knot
			Invertebrates	Echinoderm and mollusk (snail, mussel, clam) species.
			Vegetation	Significant eelgrass areas, salt marsh areas, various red, green, and brown algae
	Sable Island Intertidal	Marine intertidal zone is defined as the area of the foreshore and seabed that is exposed to the air at low tide and submerged at high tide.	Marine Mammals	Grey, Harbour, Harp, Hooded and Ringed Seals
			Birds	IBAs: Sable Island Species at Risk: Roseate Tern
			Invertebrates	Various mollusks, echinoderm species
			Vegetation	Various red, green, and brown algae
	Recreational Fisheries			Invertebrates: Bar Clams, Soft Shell Clam, Bay Quahog, Razor Clams, Clams, Oysters, Whelk
	Cultural & Subsistence			DFO Small Craft Harbours Aquaculture sites - Finfish and Shellfish Kejimikujik National Park - Seaside Adjunct Provincial Parks Privately owned Conservation Areas Nature Reserves Wilderness Areas Recreational Beaches

Table 3. Resources of Concern Developed for the Nova Scotia NEBA (based on the EIS) (*cont.*)

AREA	HABITAT	HABITAT DESCRIPTION	RESOURCE CATEGORY	REPRESENTATIVE SPECIES or SPECIFIC CONCERNS
Shelf (from subtidal zone to the shelf break)	**Sea Surface Microlayer**	The sea surface microlayer (SML) is the top 1 millimeter of the ocean surface. This is the boundary layer where exchanges occur between the atmosphere and the ocean surface.	Marine Mammals	Mysticetes: Blue whale, Fin whale, Humpback whale, Minke whale, North Atlantic right whale, Sei whale Odontocetes: Atlantic white-sided dolphin, Harbour porpoise, Killer whale, Long-finned pilot whale, Northern bottlenose whale, Short-beaked common dolphin, Sperm whale, Stripped dolphin, White-beaked dolphin
			Sea Turtles	Leatherback and Loggerhead Sea Turtles
			Birds	Large Alcids, Dovekie, Black Guillemot, Cormorants, Black Legged Kittiwake, Gulls, Jaeggers, Northern Fulmar, Northern Gannet, Phalaropes, Shearwaters, Skuas, Storm Petrels, Terns, Waterfowl
			Fish (larvae/eggs only)	Monkfish
	Water Column (*shallow less than 150m*)	The marine pelagic environment from the surface to the bottom of the photic zone to a depth of 150 m.	Marine Mammals	Mysticetes: Blue whale, Fin whale, Humpback whale, Minke whale, North Atlantic right whale, Sei whale Odontocetes: Atlantic white-sided dolphin, Harbour porpoise, Killer whale, Long-finned pilot whale, Northern bottlenose whale, Short-beaked common dolphin, Sperm whale, Stripped dolphin, White-beaked dolphin
			Sea Turtles	Leatherback and Loggerhead Sea Turtles
			Birds (diving)	Large Alcids, Dovekie, Black Guillemot, Cormorants, Black Legged Kittiwake, Gulls, Northern Fulmar, Northern Gannet, Shearwaters, Storm Petrels, Terns, Waterfowl
			Fish (larvae/eggs only)	Species at Risk: Acadian Redfish, American Plaice, Atlantic Cod Groundfish: Atlantic Halibut, Pollock, Red Hake, Silver Hake, White Hake, Yellowtail Flounder Pelagic: Atlantic Mackerel, Capelin Invertebrates: American Lobster, Scallop, Northern Shrimp, Snow Crab

Table 3. Resources of Concern Developed for the Nova Scotia NEBA (based on the EIS) (*cont.*)

AREA	HABITAT	HABITAT DESCRIPTION	RESOURCE CATEGORY	REPRESENTATIVE SPECIES or SPECIFIC CONCERNS
Shelf (from subtidal zone to the shelf break)	**Water Column (*shallow less than 150m*)**	The marine pelagic environment from the surface to the bottom of the photic zone to a depth of 150 m.	Fish	Species at Risk: American Eel, American Plaice, Atlantic Bluefin Tuna, Atlantic Cod, Atlantic Salmon, Atlantic Sturgeon, Basking Shark, Blue Shark, Cusk, Porbeagle Shark, Shortfin Mako, Spiny Dogfish, Spotted Wolffish, Stripped Bass, Thorny Skate, White Shark, White Hake Groundfish: Haddock, Hagfish, Monkfish, Pollock, Red Hake, Sandlance, Silver Hake, Witch Flounder, Yellowtail Flounder. Pelagic: Atlantic Mackerel, Bigeye Tuna, Black Dogfish, Swordfish, Yellowfin Tuna
			Invertebrates	Northern Shrimp, Shortfin Squid
			Plankton	Phytoplankton, zooplankton, copepods, ctenophores, salps, jellyfish
	Water Column (*deep greater than 150m*)	The marine pelagic environment from the edge of the photic zone (150 m) to the boundary of the benthic zone.	Marine Mammals	Mysticetes: Blue whale, Fin whale, Humpback whale, Minke whale, North Atlantic right whale, Sei whale Odontocetes: Atlantic white-sided dolphin, Harbour porpoise, Killer whale, Long-finned pilot whale, Northern bottlenose whale, Short-beaked common dolphin, Sperm whale, Stripped dolphin, White-beaked dolphin
			Sea Turtles	Leatherback and Loggerhead Sea Turtles
			Fish (larvae/eggs only)	Species at Risk: American Plaice Groundfish: Atlantic Halibut, Silver Hake, Witch Flounder
			Fish	Species at Risk: Acadian Redfish, American Plaice, Atlantic Bluefin Tuna, Atlantic Cod, Atlantic Wolffish, Basking Shark, Blue Shark, Cusk, Deepwater Redfish, Northern Wolffish, Porbeagle Shark, Roughhead Grenadier, Shortfin Mako, Spiny Dogfish, Spotted Wolffish, Thorny Skate, White Shark Groundfish: Atlantic Halibut, Haddock, hagfish, Monkfish, Red Hake, Silver Hake, Witch Flounder Pelagic: Atlantic Herring, Atlantic Mackerel, Black Dogfish, Capelin, Swordfish, Yellowfin Tuna
			Invertebrates	Northern Shrimp, Shortfin Squid
			Plankton	Zooplankton, copepods, ctenophores, salps, jellyfish

Table 3. Resources of Concern Developed for the Nova Scotia NEBA (based on the EIS) (*cont.*)

AREA	HABITAT	HABITAT DESCRIPTION	RESOURCE CATEGORY	REPRESENTATIVE SPECIES or SPECIFIC CONCERNS
Shelf (from subtidal zone to the shelf break)	Benthos	The benthic zone is the lowest level in the marine environment which includes the sediment surface as well as sub-surface layers.	Fish (larvae/eggs only)	Species at Risk: Atlantic Wolffish, Smooth Skate, Thorny Skate, Winter Skate Groundfish: Sandlance Pelagic: Atlantic Herring
			Fish	American Plaice, Atlantic Wolffish, Northern Wolffish, Spotted Wolffish, Throny Skate, Atlantic Halibut, Hagfish, Monkfish, Witch Flounder, Sandlance
			Corals & Sponges	Small and large Gorgonacea (Soft corals, Sea pens), Stony Corals, Porifera, Glass sponge
			Invertebrates	American Lobster, Jonah Crab, Scallop, Snow Crab
	Commercial Fisheries			Finfish NAFO 4X, 4W, and 5Ze (Pelagic season is open year round although high fishing activity occurs from July to November. The ground fishery is open year round, with high season from July-Sept)
				Scallop SFA 25, 26, and 27 (Fishery is open year round, with most activity occurring between May and October.)
				Crab CFA 23, 24E, and 24W (Season is open from April to September)
				Lobster LFA 31b and 32 (Season is open from April 19 - June 20)
				Lobster LFA 33/34 (Season is open from the last Monday in November to May 31)
				Lobster LFA 41 (Season is open year round)
	Cultural & Subsistence			Recreational Fishing - Pelagic and Benthic finfish Recreational Diving Recreational Boating Aboriginal Food, Social, and Ceremonial Fisheries : Finfish: American Eel, Atlantic Cod, American Plaice, Atlantic Salmon, Atlantic Herring, Atlantic Halibut, Atlantic Mackerel, Atlantic Redfish, Blue Shark, Capelin, Deepwater Redfish, Gaspereau, Haddock, Striped Bass, Pollock, Silver Hake, Smooth Flounder, Tomcod, Windowpane Flounder, Winter Flounder, Witch Flounder, Yellowtail Flounder. Invertebrates: American Lobster, American Oysters, Bay Quahog, Blue Mussels, Crabs, Scallops, Squid Mammals: Seals

Table 3. Resources of Concern Developed for the Nova Scotia NEBA (based on the EIS) (*cont.*)

AREA	HABITAT	HABITAT DESCRIPTION	RESOURCE CATEGORY	REPRESENTATIVE SPECIES or SPECIFIC CONCERNS
Slope (extending offshore from the shelf break)	**Sea Surface Microlayer**	The sea surface microlayer (SML) is the top 1 millimeter of the ocean surface. This is the boundary layer where exchanges occur between the atmosphere and the ocean surface.	Marine Mammals	Mysticetes: Blue whale, Fin whale, Humpback whale, Minke whale, North Atlantic right whale, Sei whale Odontocetes: Atlantic white-sided dolphin, Harbour porpoise, Killer whale, Long-finned pilot whale, Northern bottlenose whale, Sowerby's beaked whale, Short-beaked common dolphin, Sperm whale, Stripped dolphin, White-beaked dolphin
			Birds	Large Alcids, Dovekie, Cormorants, Black Legged Kittiwake, Gulls, Jaeggers, Northern Fulmar, Northern Gannet, Phalaropes, Shearwaters, Skuas, Storm Petrels, Terns, Waterfowl
			Sea Turtles	Leatherback and Loggerhead Sea Turtles
			Fish (larvae/eggs only)	Monkfish
	Water Column (*shallow; less than 150m*)	The marine pelagic environment from the surface to the edge of the photic zone to a depth of 150 m	Marine Mammals	Mysticetes: Blue whale, Fin whale, Humpback whale, Minke whale, North Atlantic right whale, Sei whale Odontocetes: Atlantic white-sided dolphin, Harbour porpoise, Killer whale, Long-finned pilot whale, Northern bottlenose whale, Sowerby's beaked whale, Short-beaked common dolphin, Sperm whale, Stripped dolphin, White-beaked dolphin
			Sea Turtles	Leatherback and Loggerhead Sea Turtles
			Birds (diving)	Large Alcids, Dovekie, Cormorants, Black Legged Kittiwake, Gulls, Northern Fulmar, Northern Gannet, Shearwaters, Storm Petrels, Terns, Waterfowl
			Fish (larvae/eggs only)	Species at Risk: Acadian Redfish, Deepwater Redfish Groundfish: Turbot-Greenland Flounder, Witch Flounder
			Fish	Species at Risk: American Eel, Atlantic Bluefin Tuna, Atlantic Cod, Basking Shark, Blue Shark, Cusk, Porbeagle Shark, Shortfin Mako, Spiny Dogfish, Spotted Wolffish, Thorny Skate, White Shark Groundfish: Monkfish, Red Hake, Silver Hake, Turbot-Greenland Flounder, Witch Flounder Pelagic: Albacore Tuna, Bigeye Tuna, Swordfish, White Marlin, Yellowfin Tuna

Table 3. Resources of Concern Developed for the Nova Scotia NEBA (based on the EIS) (*cont.*)

AREA	HABITAT	HABITAT DESCRIPTION	RESOURCE CATEGORY	REPRESENTATIVE SPECIES or SPECIFIC CONCERNS
Slope (extending offshore from the shelf break)	**Water Column (*shallow; less than 150m*)**	The marine pelagic environment from the surface to the edge of the photic zone to a depth of 150	Invertebrates	Shortfin Squid
			Plankton	Phytoplankton, zooplankton, copepods, ctenophores, salps, jellyfish
	Water Column (*deep; greater than 150m*)	The Marine pelagic environment from the edge of the photic zone (150 m) to the boundary of the benthic zone.	Marine Mammals	Mysticetes: Blue whale, Fin whale, Humpback whale, Minke whale, North Atlantic right whale, Sei whale Odontocetes: Atlantic white-sided dolphin, Harbour porpoise, Killer whale, Long-finned pilot whale, Northern bottlenose whale, Sowerby's beaked whale, Short-beaked common dolphin, Sperm whale, Stripped dolphin, White-beaked dolphin
			Sea Turtles	Leatherback and Loggerhead Sea Turtles
			Fish (larvae/eggs only)	Species at Risk: Roundnose Grenadier
			Fish	Species at Risk: Acadian Redfish, Atlantic Bluefin Tuna, Atlantic Cod, Atlantic Wolfish, Basking Shark, Blue Shark, Cusk, Deepwater Redfish, Northern Wolffish, Porbeagle Shark, Roughhead Grenadier, Roundnose Grenadier, Shortfin Mako, Spiny Dogfish, Spotted Wolffish, Thorny Skate, White Shark Groundfish: Atlantic Halibut, Hagfish, Monkfish, Red Hake, Silver Hake, Turbot-Greenland Flounder, Witch Flounder Pelagic: Albacore Tuna, Bigeye Tuna, Black Dogfish, Swordfish, Yellowfin Tuna
			Invertebrates	Shortfin Squid
			Plankton	Zooplankton, copepods, ctenophores, salps, jellyfish
	Benthos	The benthic zone is the lowest level in the marine environment which includes the sediment surface as well as sub-surface layers.	Fish	Atlantic Wolffish, Northern Wolffish, Spotted Wolfish, Thorny Skate, Monkfish, Turbot-Greenland Flounder, Witch Flounder
			Corals & Sponges	Small and large Gorgonacea (Sea whilps, Sea pens, Soft corals), Black coral, Stony cup coral
			Invertebrates	Snow Crab
	Commercial Fisheries			Finfish NAFO 4X, 4W, and 5Ze (Pelagic season is open year round although high fishing activity occurs from July to November. The ground fishery is open year round, with high season from July-Sept)

Table 3. Resources of Concern Developed for the Nova Scotia NEBA (based on the EIS) (*cont.*)

AREA	HABITAT	HABITAT DESCRIPTION	RESOURCE CATEGORY	REPRESENTATI/VE SPECIES or SPECIFIC CONCERNS
Slope (extending offshore from the shelf break)	**Cultural & Subsistence**			N/A
Special Areas	**Gully Marine Protected Area**	The Gully Marine Protected Area is located approximately 200 km southeast of Nova Scotia, east of Sable Island, on the edge of the Scotian Shelf. The seafloor drops off to 2500 m into a large submarine canyon which is home to a rich diversity of marine habitats and species.		Mysticetes: Blue whale, Fin whale, Humpback whale, Minke whale, North Atlantic right whale, Sei whale Odontocetes: Atlantic white-sided dolphin, Harbour porpoise, Long-finned pilot whale, Northern bottlenose whale, Sowerby's beaked whale, Short-beaked common dolphin, Sperm whale, Stripped dolphin, White-beaked dolphin Corals and sponges: Small and large Gorgonacea, Black coral, Sea Pens, Soft Coral, Porifera
	Roseway Basin	The Roseway Basin is located on the Scotian Shelf off of Southwest Nova Scotia, between Baccaro and Browns Banks. This Basin is critical habitat for the endangered North Atlantic Right Whale (Schedule 1 of SARA)		Mysticetes: North Atlantic Right Whale

Figure 6 and 7 below provide the reader a general introduction to the Project area. Shoreline classification information, provided through Environment Canada, is captured in Figure 6 to illustrate the varied shoreline habitat along the southern tip of Nova Scotia. Areas noted as important fisheries locations are shown in Figure 7. Spatial information denoted on Figure 7 was gathered as part of stakeholder engagements associated with the EIS and NEBA.

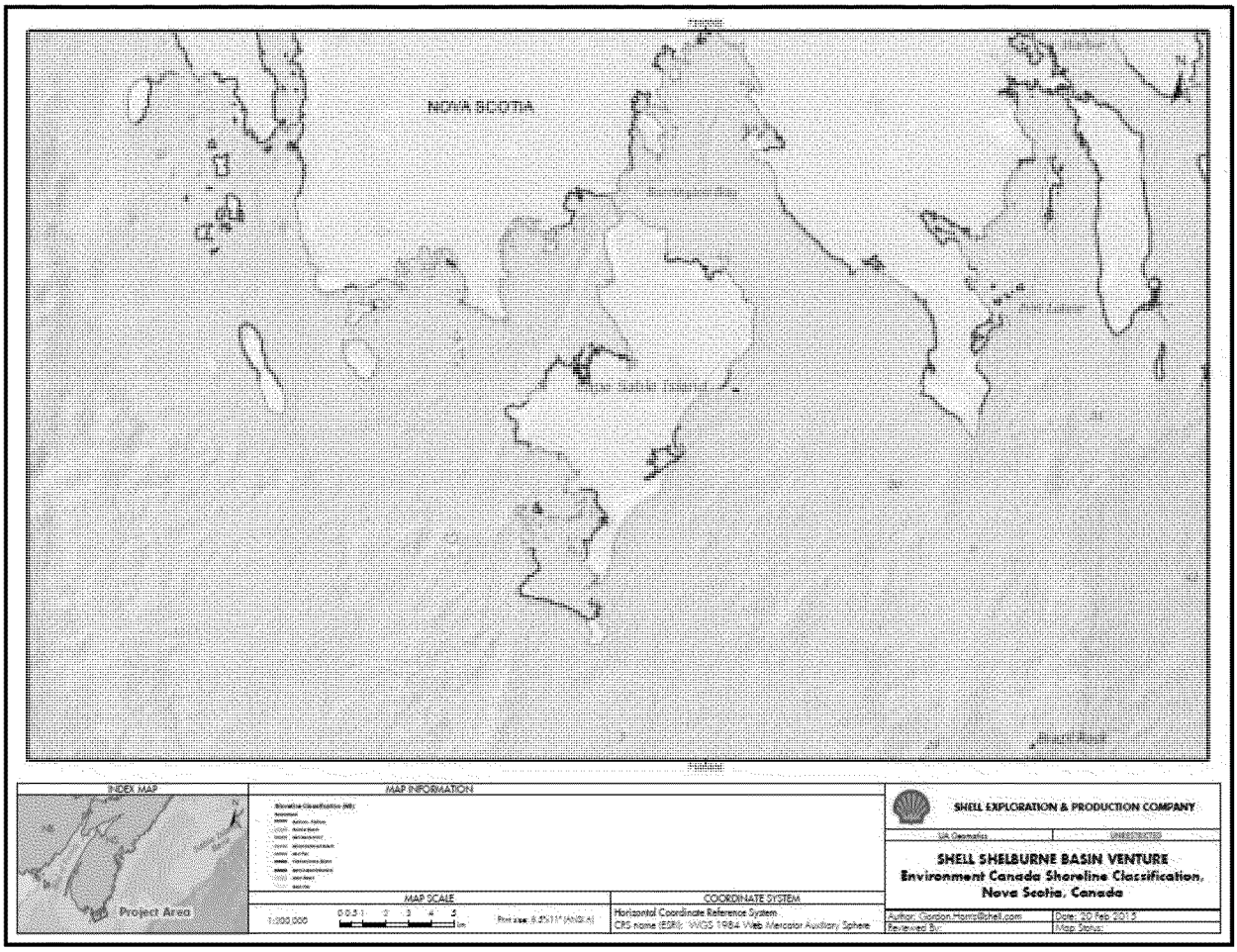

Figure 6. Shoreline classification map for the Nova Scotia region

In association with the NEBA analysis, Shell has engaged with various federal and provincial regulators, as well as Aboriginal peoples and members of the public, regarding Resources of Concern and the associated analysis. Additionally, there was active stakeholder participation in the development of the EIS, and the reader is encouraged to review the detailed information provided in that document (Stantec, 2014a,b). Table 4 provides a summary of stakeholder engagement undertaken in association with the NEBA analysis.

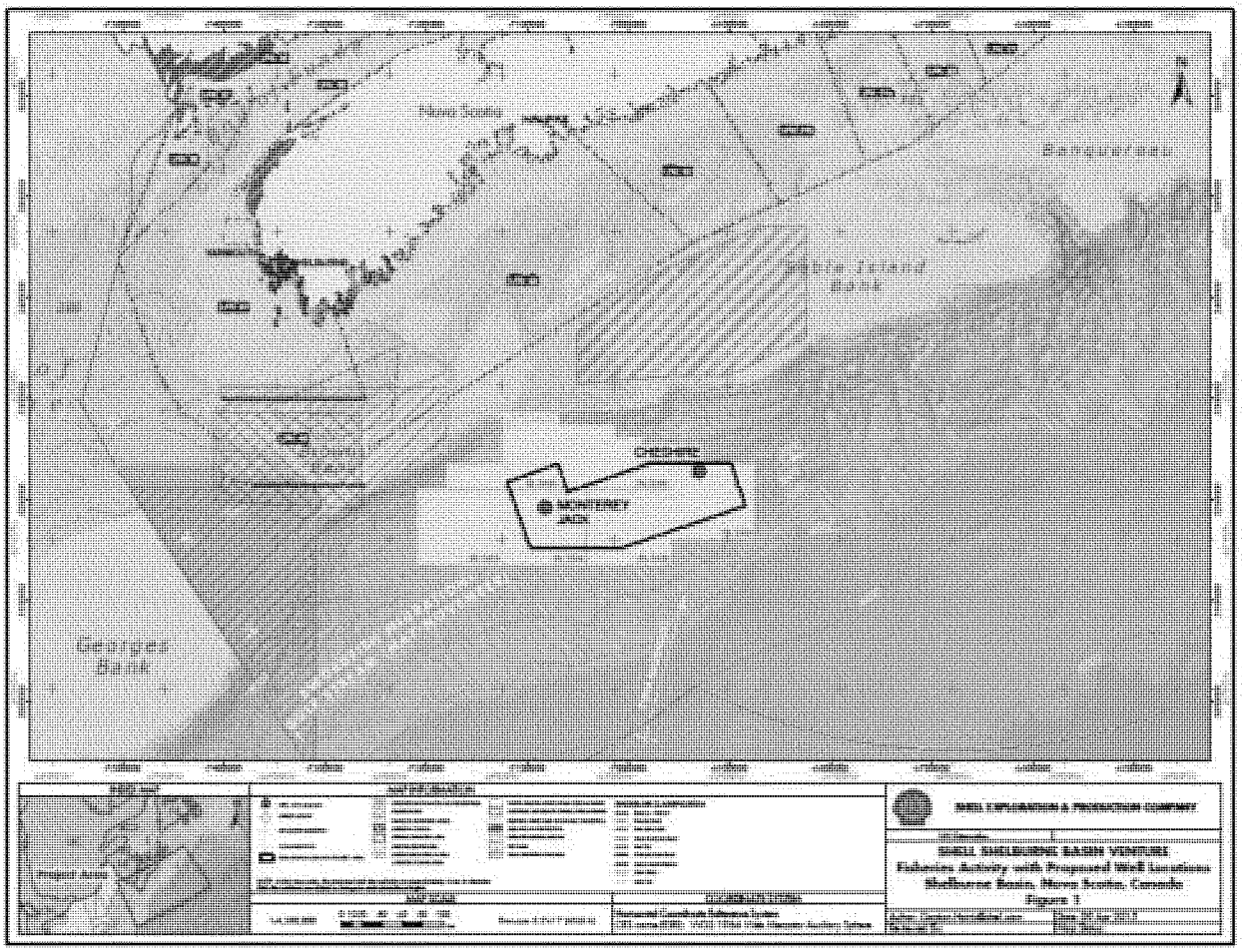

Figure 7. Map depicting important fisheries within the Project area

Table 4. Summary of NEBA Stakeholder and Aboriginal Engagement

Organization	Format	Purpose	Location	Date
Fisheries and Oceans Canada (DFO) DFO – Canadian Coast Guard (CCG)	Workshop	Overview of NEBA Methodology and Results Spill Response Measures	Montreal, QC	Dec 8, 2014
Environment Canada (EC) – National Environmental Emergencies (NEEC) Science Table				
CNSOPB				
Mi'kmaq of Nova Scotia	Workshop	Spill Response Measures NEBA Methodology and Results	Millbrook, NS	Feb 9, 2015
Mi'kmaq of Nova Scotia	Workshop	Spill Response Measures NEBA Methodology and Results	Membertou, NS	Feb 10, 2015
Fisheries Stakeholders (Fisheries Advisory Committee +)	Workshop	Spill Response Measures NEBA Methodology and Results	Halifax, NS	Feb 11, 2015
New Brunswick First Nations (St. Mary's, Woodstock, Fort Folly, Assembly of NB First Nation Chiefs)	Workshop	Spill Response Measures NEBA Methodology and Results	Fredericton, NB	Feb 12, 2015
St. Mary's First Nation	Conference Call	Proposed manner of Consultation	Halifax, NS	Mar 26, 2015
Assembly of New Brunswick First Nation Chiefs (ANBFNC)	Conference Call	Proposed manner of Consultation	Halifax, NS	Mar 27, 2015
KMKNO	Conference Call	Proposed manner of Consultation	Halifax, NS	Mar 30, 2015
Fisheries Stakeholders (FAC +)	Information Session	Spill Response Measures NEBA Methodology and Results	Halifax, NS	Apr 24, 2015
New Brunswick First Nations (Woodstock, St. Mary's, Fort Folly, ANBFNC)	Information Session		Fredericton, NB	Apr 27, 2015
Millbrook Chief and Council	Letter	Request for meeting	Millbrook, NS	May 19, 2015
Eskasoni Chief and Council	Letter	Request for meeting	Eskasoni, NS	May 19, 2015
Acadia Chief and Council	Letter	Request for meeting	Acadia, NS	May 19, 2015
Millbrook First Nation	Information Session	Spill Response Measures NEBA Methodology	Millbrook, NS	May 28, 2015
Mi'kmaq Fisheries Managers	Information Session		Millbrook, NS	Jun 18, 2015

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2.3 Response Options

The six response options considered in this analysis are summarized below from an operational and logistics perspective. Shell has prepared a detailed Oil Spill Response Plan (OSRP) as well as an Aerial and Surface Dispersant Operations Pl an for the Project. T he reader is encouraged to review that plan for further operational information on the individual response option s. It is important to recognize that during a spill, the best response almost always results when a combination of response techniques are used together to minimize ecological damage and promote the fastest overall recovery of the ecosystem. So while the resp onse options are considered individually in this document, it is understood that multiple responses will likely be used during a real spill.

Where necessary for the analysis, scenario -specific information is included in the description. The operational benefits and limitations for all of these response options are summarized in Table 5. Potential environmental impacts are the focus of later analysis in the document.

Table 5. Operational Summary of Response Options (Modified from IPIECA 2013)

Response Option	Benefit	Limitation
Natural Attenuation	• No intrusive removal or cleanup techniques that further damage the environment • May be best option if there is little to no threat to human or environmental well-being • When selected for certain areas and conditions, the environment can recover from the spill more effectively than it might when using other response tools	• Winds and currents can change, sending the oil spill toward sensitive areas • Residual oil can impact shoreline ecology, wildlife, and economically relevant resources • Public perception that responders are doing nothing
Shoreline Protection & Recovery	• Booming can be strategically planned to protect sensitive areas • Non-aggressive methods can have minimal impact on shore structure and shore organisms while reducing the amount of stranded oil • Useful for detailed cleaning of near shore environment in specific or sensitive areas • Recovered oil can be recycled	• Aggressive removal methods may impact shoreline and shore organisms (e.g., sand removal and cleaning) • Potential for heavy equipment and high foot traffic (trampling) can cause additional environmental damage • Removal occurs after oil has already impacted shore • Labor-intensive and weather dependent
On-water Mechanical Recovery	• Permanently removes oil from the water, thereby preventing shoreline impacts • Well-accepted, no special approvals needed • Effective for recovery over wide range of spilled products • Large "window of opportunity" • Minimal side effects • Greatest availability of equipment and expertise • Recovered product may be reprocessed	• Inefficient and impractical on thin slicks • Ineffective in inclement weather or high seas • Requires storage capability • Typically recovers no more than 10 percent of the oil spilled in open ocean environments, more may be recovered in other conditions • Labor- and equipment-intensive

Table 5. Operational Summary of Response Options (Modified from IPIECA 2013) *(cont.)*

On-water In-situ Burning	• High oil elimination rate possible • No recovered oil storage requirements • Effective over wide range of oil types and conditions • Specialized equipment (boom) is air transportable • Minimal environmental impact	• Special approvals required • Ineffective in inclement weather or high seas • Black smoke perceived as significant impact on people and the atmosphere • Localized reduction of air quality • Specialized equipment and expertise required • Burn residue can be difficult to recover
Dispersants – Water Surface	• High aerial coverage rate possible at the water surface • Large volumes of oil can be treated • Potentially high oil elimination rate • Reduced vapors at the water surface; improves safety • No recovered oil storage requirements • Lower manpower requirements • Potentially the quickest response option • Prevents oil from spreading to shoreline • Useful in higher wind and sea conditions • Effective over wide range of oil types and conditions	• Special approvals required • Perceived to be unsuitable for calm seas • Short-term, localized reduction in water quality • Potential impact on water column ecology • Specialized equipment and expertise required • Will not work on high viscosity fuel oils in calm, cold seas • Has a limited "window of opportunity" for use
Dispersants – Subsea Injection	• Large volumes of oil can be treated with high efficiency • Potentially high oil elimination rate • Reduced vapors at the water surface; improves safety • No recovered oil storage requirements • Lower manpower requirements • Prevents oil from spreading to shoreline • Useful in wind and sea conditions that would inhibit other response options • Effective over wide range of oil types and conditions • Applications can be performed continuously – 24 hours, 7 days a week	• Less known about long term effects of subsea use • Special approvals required • Short-term, localized reduction in water quality • Potential impact on water column ecology • Specialized equipment and expertise required •

2.3.1 Natural Attenuation

Natural attenuation is a response option involving no human intervention to influence the fate of the spilled product. In association with this analysis, it represents the baseline against which all of the other response options are compared. With natural attenuation, the spilled oil will drift with the winds and currents, gradually weathering until it evaporates, dissolves, and disperses into the water column, or

strands on the shoreline. Once stranded, weathering will continue and the oil will gradually biodegrade or be incorporated into the sediments. Portions of the relatively fresh oil may be released from the shoreline and redistributed several times until it finally degrades, is consumed by organisms, or is deposited permanently.

Benefits: Natural attenuation may be an appropriate option for spills at sea which do not threaten shoreline or protected habitats, or during periods of high sea state (winter months, storm events) which facilitate natural dispersion and may prevent other response options from being deployed . It may also be appropriate for certain sensitive shoreline habitats where intrusion by peopl e and equipment may cause more environmental damage than allowing the oil to degrade naturally . It could be necessary where recovery and cleanup are not feasible.

Logistics: Remote sensing , real time modelling and m onitoring at sea and on potentially affected shorelines would be implemented to track the fate of naturally weathering oil slicks.

Limitations: Not providing any intervention can result in negative public perception as there is typically a public expectation that an attempt will be made to remove the spilled product from the environment. Natural attenuation is a p assive response option which will not protect high value shoreline habitats in the unlikely event the oil reaches shore. Natural attenuation may also result in persistence of oil slicks at sea surface, which may range from hours for light oil in high seas to months for heavier or emulsified oils in relatively quiescent conditions. S horeline recovery may take weeks or up to months or years, depending on the type of oil spilled and dif ferent environmental variables (i.e., wave energy, amount of solar exposure, rainfall, shoreline erosion processes). Reliance on natural attenuation can also affect emergency response capabilities at the well site, as it will not reduce the potential for e xposure of surface vessels and personnel to volatile components of the oil which can create a health and safety risk.

Efficiency: The term "efficiency" in oil spill response refers to how well a mobilized response technique will work. In this case, the efficiency of "doing nothing" cannot be measured. However, natural attenuation (sometimes referred to as a "monitor and wait" approac h) can be an effective option, especially in extreme weather conditions when high energy can effectively disperse the oil naturally.

2.3.2 Shoreline Protection and Recovery

Shoreline protection (e.g., diversion and deflection booming of oil) and recovery (manual retrieval of oil) are two response techniques that are usually used in combination, so they are addressed together in this section. The trajectory modelling for the Project demonstrates that there is a very low likelihood of spilled oil reaching the shor eline. However, in the unlikely event where it may reach shore, ways to safeguard the shoreline from spill impacts include shoreline protection and recovery. Shoreline protection and recovery are considered important tool s when oil cannot be effectively t reated or collected on-water prior to encounter with shoreline areas.

Protective booming strategies may vary depending on tides, currents and weather conditions. However, these static boom systems require relatively quiescent waters as protective booms wi ll likely fail in sea states above 1-2 meters, High winds can also blow the oil past the boom, and tides and currents can also pose a challenge. For the specific spill scenario considered, the remote location of the spill site (i.e., 250 km from shore) and the degree of oil weathering predicted, the options listed below are the most appropriate shoreline recovery options that may be utilized if oil does reach shorelines:

- Manual Removal – removal of surface oil by manual means (hands, rakes, shovels, buckets, scrappers, sorbents, etc.)
- Debris Removal – manual or mechanical removal of debris (oiled and unoiled) from the shore or water surface to prevent additional sources of contamination.
- Low pressure cold water flushing
- Limited use of mechanical recovery equipment in accessible areas if justified by the contamination level.

Benefits: Protective booming can protect relatively short stretches of the coast and as such should be used strategically in selected areas such as protecting lagoons, backwater entrances, marshes, or other sensitive areas. Protective booming should be used strategically to the extent practical based on current forecasted spill trajectory, the environmental context and conditions at the time of the incident. Once oil reaches the shoreline, the potential benefits of shoreline recovery options relative to natural attenuation include the following:

- Reduction in impact to shorelines, sensitive habitats, birds, mammals, and other wildlife
- Physical removal of oil from the environment
- Recycling or proper disposal of recovered oil.
- Mitigation of impacts to culturally or economically important areas such as those used for nearshore fisheries, gathering, tourism and recreation activities.

OIL AND SEDIMENTS

The concern about the ecological consequences of oil in sediments is valid. Studies from large oil spills (*Exxon Valdez*, *Sea Empress*, and Gulf War spills) have shown that weathered oil that strands in intertidal or subtidal habitats such as mudflats or marshes can persist for years. This can be exacerbated by manual cleanup efforts if personnel walk over sensitive areas and embed the oil deeper into the sediments with their footsteps or tools, or by natural processes that drive the oil below the surface. Once the oil is driven below the surface into anoxic zones, natural weathering and biodegradation processes occur much more slowly (Sauer *et al.*, 1998). One experimental study conducted in an Atlantic Canada salt marsh concluded that, once oiled, the best response action is natural attenuation (Lee *et al.*, 2003). Typically the public does not respond well to the idea of *not* cleaning up the oil in critical shoreline habitats.

Alternatively, the better response option should be to prevent the oil from approaching these shoreline environments in the first place and instead should focus on responding to the oil while it is still at sea.

Logistics: Both shoreline protection and recovery tend to be labour intensive and involve large numbers of responders who must be trained, transported, housed, and managed. The logistics associated with such operations can be complex, particularly if they are to occur in remote areas or adverse weather conditions such as those that may be experienced in offshore Nova Scotia. In addition worker personal protective equipment, hand tools, washing equipment, protective and containment boom, and any

appropriate mechanical equipment must be provided, stored, transported and maintained. Difficulties in gaining access to impacted shorelines due to logistic or topographical obstacles can all make shoreline protection and recovery operationally difficult and it may not be possible to implement such options in all potentially affected areas due to logistical constraints. The reader is referred to the OSRP for equipment, mobilization and deployment planning for the Project.

Limitations: Typically shoreline protection activities can be applied to only relatively short stretches of the coast and as such must be used strategically in selected areas such as protecting lagoons, backwater entrances, marshes and other sensitive, ecologically important, or socially important areas. While protective booming can be valuable, it can also create a risk of collateral damage due to physical disturbance by work crews installing, maintaining and dismantling the boom. This may include disturbance and scaring from anchoring the materials to soils, sediments or plants, along with increased erosion of shoreline and sediments while the boom jostles in place. This potential damage is considered minor relative to the damage likely to result from the oil itself left unmitigated. The use of protective boom is also highly dependent on weather, type of shoreline, topography and hydrographic conditions.

For shoreline recovery, heavy machinery on beaches and intrusion by humans on foot can have negative impacts on some shoreline habitats. In marsh and wetland habitats, the activity associated with the cleanup can often be more damaging than the oil itself; the cleanup operations can drive the contaminants below the surface and make them available to the root systems of the plant and the organisms that burrow into the sediments. It is common in these environments for oil to be allowed to remain on the surface of the sediments with sorbents being placed at the edge of the water line in an effort to passively collect any oil that re-floats. Shoreline recovery tends to be more environmentally intrusive than any of the on-water response options. Given the logistics and limitations, on-water cleanup will almost always be environmentally preferable to on-shore recovery, with a goal to preventing the oil from reaching the shoreline in the first place.

Efficiency: The efficiency of protective booming is highly variable. The degree of protection afforded depends on factors such as the type of oil, local currents and wave conditions, installation methods, boom maintenance, and the degree to which a shoreline is accessible with equipment and amenable to placement of protective (diversion) booming. Even properly installed booms can protect only relatively short segments of a coastline and cannot provide protection to the entire shoreline if a widespread slick is approaching from the offshore. An additional consideration is that the efficiency of protection commonly decreases as the duration of oiling and amount of oil impinging on the boom increases. Oily booms need to be serviced on a regular basis or they can become a source of oil for the local area it was intended to protect.

Depending on the spill conditions and the response operation used, the shoreline recovery strategies can range from 100 % effective in shoreline types such as sandy beaches, where heavy equipment and personnel have easy access, to minimally effective in the case of marshes and sheltered tidal mud flats where any type of access by humans or equipment can drive oil deep into sediments, resulting in no recovery. Additionally, once shoreline recovery begins, determination of "how clean is clean" can make decisions regarding termination difficult. Shoreline cleanup is an extensive topic and documents such as Environment Canada's "A Field Guide to Oil Spill Response on Marine Shorelines" (Owens and Sergy, 2010), and the Shoreline Assessment Manual, 4th Edition (NOAA, 2013) are valuable references for the

reader to gain a better understanding of the various cleanup methods, effectiveness associated with each method, and cleanup endpoints.

2.3.3 On-water Mechanical Recovery

On-water mechanical recovery is defined as the removal of oil from water using mechanical equipment (i.e., skimmers and booms) to redirect and remove oil from the surface of the water. This recovered oil is collected for disposal and possible reuse to prevent or minimi ze impacts to sensitive near shore and offshore habitats. The success rate of oil removal by means of on-water mechanical recovery is dependent upon factors such as wind, waves, and daylight.

Benefits: This respons e option permanently removes both fresh and weathered oil states from the water and prevents distribution of the spill in the environment through processes such as natural or chemically induced dispersion, evaporation, or physical transport by currents. When recovered at sea, the threat to shore line resources is mitigated because less oil becomes stranded and shoreline protection and recovery operations are reduced or eliminated. Recovery operations tend to have minimal side effects on wildlife. Mechanical recovery also provides the greatest rang e of equipment options and is one of the most practiced and understood of the oil spill response options.

Logistics: The equipment needed to carry out mechanical recovery of a large scale oil spill will involve a large number of skimming vessels, support vessels, storage barges, spotter aircraft and large quantities of collection boom. The equipment will need to be transported to the spill site, which in this instance is approximately 250 km offshore. Collected oil will need to be stored and ultimately ret urned to shore for disposal. Given the distance offshore, the logistics associated with a large -scale release would be complex and challenging. On water mechanical recovery may have only localized capability and benefit. The reader is referred to the OSRP for equipment mobilization and deployment planning for the Project.

Limitations: Although there will be recovery vessels in the area available to assist with the immediate response, these vessels will have a limited recovery capability. As a result, t here will be a lag time from the time of the spill to the time of conducting mechanical recovery on a large scale , reducing the window of opportunity to conduct mechanical recovery. Light oil rising to the surface is likely to form very thin sheens which will reduce efficiency of oil collection at the surface. The longer the oil is left in the water, the more it disperses and thins making it more difficult to recover. Besides the encounter rate, weather con ditions and day length would also be critical in this a rea. Open water boom begins to fail in sea states with w aves over approximately 2 m, which occur approximately 80% of the time in the winter and 20 to 25% of the time in the summer within the RAA (Stantec 2014a). While day length is not an issue in the summer, it will be in the winter, reducing the window of opportunity even more. When sea states are conducive for booming and on -water skimming, mechanical recovery techniques typically recover no more than approximately 10%of the oil spilled in open ocean environments.

Efficiency: On-water mechanical recovery on the open ocean is limited by climatic and hydrographic conditions, oil weathering and the encounter rate. Even when conditions are favorable, after action

reports from previous large offshore spills indicate recovery of 5 to 10% of spilled volume is the maximum that can be expected. At Deepwater Horizon (DWH) the estimate was less than 5%.[1]

2.3.4 On-Water In-situ Burning

On-water in-situ burning (ISB) involves the collection of oil in specially designed fireproof booms (as in on-water recovery), followed by removal of the oil from the water surface through burning. This response option is advantageous in the fact that it reduces oil storage and disposal. ISB has the same weather and day light condition limitations as on -water mechanical recovery . It is preferentially conducted under e ven lower wave heights (less than 1.2 m) , and with plenty of available daylight to monitor and track the burn as well as to allow for ignition and control.

Benefits: This response option can permanently remove encountered oil from the water at high rates (if there are prevailing low sea states of less than 1.2 m to maintain the oil in the boom) and reduces the amount of oil remaining for collection and disposal. The technique is effective for a wide range of oils. As a result, ISB can minimize the spread of a spill and the resources and time needed for a response.

Logistics: Equipment needs are similar to on-water mechanical recovery, with the addition of fire boom and ignition capability. It should be noted that the approval process for ISB may also require either an enhanced monitoring aircraft or ground -based smoke-plume air quality monitoring to be implemented, so logistics consideration should be given to mobilizing scientific teams and equipment for this purpose. The reader is referred to the OSRP for equipment mobilization and deployment planning for the Project.

Limitations: The decision to use ISB is dependent on the feasibility under existent environmental conditions at the time of an incident and regional government policies- some guidance is available in the "British Columbia/Canada In -situ Oil Burning Policy and Decision Guidelines" (DFO, EC, BC Ministry of Environment, Lands and Parks 2001). Reductions in air quality due to gases and particulate material may be a concern in some jurisdictions (if there are populated areas nearby) and ISB creates limited by - product burn residues that can sink into the ocean and cannot be recovered. Limitations related to weather, encounter rates and day length are similar to on-water mechanical recovery. It is preferentially conducted in low wave heigh ts (less than 1. 2m), and with plenty of availably daylight to monitor and track the burn as well as to allow for ignition and control. The availability of fire boom, which becomes unusable over time, would be a factor in a spill of the extent and duration assumed for this study. Oil is likely to be easily ignitable when fres h, but will become less suitable for burning as it weathers and emulsifies. Additionally this response option is inefficient and impractical on thin slicks.

Efficiency: ISB is a response technique that is highly dependent on the prevailing environmenta l conditions and the encounter rate. For these reasons, ISB would not likely result in the removal of large amounts of oil in this Project area because wave heights in the North Atla ntic are typically above the 1.2 m needed to maintain the oil in a fire boom. At DWH, where sea states were typically quite low throughout the response, estimates were that 5% of the oil was removed by burning, which is more

[1] Estimate based on "Oil Budget Calculator: Deepwater Horizon" report by The Federal Interagency Solutions Group, Oil Budget Calculator Science and Engineering Team (November 2010).

than would be expected offshore Nova Scotia where sea states would typically not support the fire booming operation (Allen *et al.*, 2011).

2.3.5 Dispersant Application at Water Surface

A general overview of dispersants was provided in the EIS , and a primer on dispersants is provided in Appendix A. The reader is referred to this appendix for a broader discussion on this topic. Dispersants may be applied to the affected water surface from airplanes, helicopters and/or vessels. Dispersant spray systems are designed to provide the correct droplet size a nd dosage, as both are important factors in effective oil dispersal. The volume of dispersant applied is a fraction of the volume of oil treated . Responders make a judgment on what dispersant to oil ratio (DOR) should be employed based on the type of oil s pilled, its thickness, and its degree of weathering. When the oil is treated with dispersants at the water surface , it disperses with in the upper 10 m of the water column due to natural mixing processes . This mixing is primarily driven by wave action and w inds, and to a lesser degree rain and possibly surface currents . If these dispersed oil droplets are small enough (generally 10-100 micrometer) the droplets will remain dispersed in the water column , and serves as a positive indication of effective oil dispersion (Lunel, 1993; Li *et al*., 2009 a,b). Chemically dispersed oil droplets are typically smaller than naturally dispersed oil droplets and have a reduced interfacial tension (due to the surfactant provided by the dispersant). These smaller chemically dispersed droplets form stable oil-in-water emulsions which are much less likely to re -coalesce into a surface slick (compared to naturally dispersed oil droplets). The dispersed oil will then be rapidly diluted due to spreading both horizontally and ver tically by tides and currents and will naturally biodegrade. Additional information on biodegradation

DILUTION RATES RESULTING FROM DISPERSANT APPLICATION

Much of the literature on the toxicity of dispersants and dispersed oil is based on 48 - or 96-hr LC50 studies where the test organisms are exposed to a constant concentration of dispersant or dispersed oil for relatively prolonged periods. Prolonged and constant exposure to very high concentrations of dispersed oil in a laboratory setting (in order calculate LC50 values) is considerably different from the likely exposure regime experienced by marine organisms in the open sea following an oil spill, as evidenced by analytical results from several field trials conducted in the North Sea to assess fate and effects of dispersant use on an open ocean oil slick.

These field experiments and the subsequent chemical characterization conducted in 1994 (AEA Technology, 1994), 1995 (AEA Technology, 1995; Jones and Petch, 1995), and 1996 (Strøm - Kristiansen *et al* ., 1997; Coelho *et al* ., 1998) showed rapid (within one hour) dilution of dispersed oil concentrations following dispersant application. Further evidence of the rapid dilution of dispersed oil can be found from exten sive studies during the DWH spill (OSAT*, 2010), in which more than 11,397 water and sediment samples were analyzed, and findings indicate that less than 1% water and sediment samples exceeded aquatic toxicity benchmarks.

** OSAT is the inter -agency team fo rmed to compile, analyze and interpret the data generated from the DWH large -scale sampling and monitoring program.*

processes is provided in Appendix A. Historically, initial dispersed oil concentrations of 20 to 50 parts per million (ppm) have been reported in the upper 10 m of the water column directly under the slick. These concentrations dilute rapidly as the oil moves through time and space in the water column and degrade. Within 2-4 hours, concentrations typically decrease to below 10 ppm, which is approaching the threshold limit below which adverse ecological effects are not anticipated, even to sensitive species (NRC, 2005).

Benefits: The use of dispersants on the surface of the water applied from either vessels or aircraft can substantially reduce the amount of oil that may impact shorelines or has to be recovered. It reduces the potential smothering of or oiling ingestion by wildlife that use surface waters in or near a spill. The application of dispersants can also be performed on a large areal scale and in high sea conditions, thereby increasing the response time and effectiveness for reducing a spill's impact. When a surface spill has been treated with chemical dispersants, the oil can be rapidly diluted in a large volume of water to very low concentrations. Finally, the dispersed oil is also more susceptible to biodegradation – hence, it is removed more quickly from the environment.

DISPERSANT EFFECTIVENESS ON COLD WATER SPILLS

There has some skepticism about the effectiveness of dispersant use in cold water environments. However, both open ocean field studies and mesocosm studies have indicated that modern day dispersant formulations work very well in these conditions. Several studies have been conducted in the North Sea (AEA Technology 1994, 1995; Brandvik *et al.*, 1996) measuring high dispersant effectiveness on Forties Crude oil, which is a light crude similar to what is expected in this Project area. Not only did the study show high effectiveness, it also measured rapid dilution in the top 10 m of the water column within two hours of aerial application. More recently, a study conducted in the Ohmsett* facility tested four different oils and two different dispersants in very cold water conditions. The authors of this study reported 85-99% effectiveness of the dispersant on both fresh and weathered oil in very cold water conditions (Belore *et al.*, 2009).

** Ohmsett refers to the National Oil Spill Response Research & Renewable Energy Test Facility located in New Jersey, USA. It is the largest outdoor saltwater wave/tow tank facility*

Logistics: In the spill scenario analyzed for the NEBA, dispersant application from large, fixed wing aircraft is the most likely mode of application. Spotter aircraft will also be important for this response option to assist in spatial and situational awareness. Sufficient aircraft, dispersant supplies, and maintenance capabilities, along with multiple trained crews and observers will be needed to maintain continuous daylight operations. Staging of aircraft will be on the mainland, a minimum of 250 km away. The reader is referred to the OSRP for equipment mobilization and deployment planning for this Project. It should be noted that the aerial dispersant approval process may also require a surface dispersant monitoring plan to be implemented, so logistics consideration should be given to mobilizing scientific teams and equipment for this purpose. There are SMART guidelines available for monitoring surface dispersant operations (USCG *et al.*, 2006), and the reader is referred to a publication by Trudel *et al.* (2009) for other considerations on aerial dispersant monitoring.

Limitations: Aerial dispersant operations require 1000 feet (~300 m) minimum cloud ceiling, 3 statute miles (~5 km) forward visibility, daylight, and wind speeds less than 40 mph (~ 65 km/hr) to ensure safety of aircraft. Special approvals may be required by the Canadian regulating agency for aerial dispersant application. While Canadian policy is not yet established at the time this document has been prepared, regulatory policy in other parts of the world frequently require a minimum distance from shore (approximately 3 nautical miles) and a minimum water depth (approximately 10 m) for aerial dispersant application. Other "exclusion zones or conditions" may be set by regulatory policy. Surface dispersant application also has a limited "window of opportunity" and may be less effective in calm waters (when no wave action is present).

Efficiency: Dispersant effectiveness is dependent on the type of oil and environmental conditions present during the scenario. Dispersant effectiveness can approach 100% when the freshest oil closer to the source is targeted. Note that this high effectiveness is for oil that is actually treated with the dispersant, not for the slick as a whole, so while the effectiveness is high, the encounter rate for a large spill may be low. Effectiveness can be difficult to verify because the dispersant action may occur over a long period of time, and wind and currents may carry the oil from the application area. Trained observers must be used to verify effectiveness. In this scenario, factors such as weather, visibility, day length and logistics will limit the encounter rate of aerial application and the overall efficiency. Despite these limitations, modelling assumptions for this scenario use a 100% dispersant efficiency (for that oil that can be treated, or encountered, by aerial dispersant sorties) in order to analyze the maximum amount of dispersed oil that could be present in the water column and the potential associated ecological effects.

2.3.6 Subsea Dispersant Injection

The DWH spill in 2010 represents the first application of subsea dispersants where dispersants were applied at the well head opening on the sea floor. The same general chemical dispersion principles that were discussed in Section 2.3.5 apply here as well, except for a few key distinctions. The flow rate of oil in a deepsea release will vary on reservoir pressure, gas-oil-ratio, and orifice size. Near the release source, intense turbulence and high pressures will result in the oil flow quickly separating into a wide variety of oil droplet sizes. The dispersant injection is focused at the release point and is intended to rapidly reduce those droplet sizes to a range where the droplets are neutrally buoyant, and to prevent those droplets from re-coalescing and quickly rising to the surface. The complex processes are a focus of ongoing research, but the reader is directed to a recent publication by Brandvik *et al.* (2014) for an overview of subsurface oil release behavior and droplet size distribution (at depth) with and without dispersant treatment.

Benefits: With subsea injection the encounter rate is extremely high because the dispersant is being applied directly to the oil source as it is released into the water, before the oil begins to rise and spread horizontally and vertically within the water column. Because of the high encounter rate, DORs of 1:50 to 1:100 should be sufficient to effectively disperse the oil. The higher DOR means that less dispersant (and therefore less solvent) is required for subsea dispersant injection versus aerial dispersant application. Because the injection is occurring at the sea floor, the dispersed oil will dilute vertically over a much greater volume of water. The spill's transit at depth will be driven by buoyancy of the dispersed oil droplets (vertically) as well as by the influence of deep ocean currents (horizontally). This rapid dilution equates to lower concentrations of dispersed oil than those typically measured after a surface

application (where the dispersed oil is typically limited to 10 m of vertical dilution). The dispersed oil will naturally biodegrade in these cold, deep waters . Additional information on biodegradation processes is provided in Appendix A. During the DWH spill event, measured dispersed oil concentrations at about 1 km distance from the well head at 1200 m depth were consistently well below 5 ppm (Coelho *et al*., 2012). Subsea dispersants may be an ideal response tool as the operations can run at all hours with little impact from severe weather. It also provides dispersant application at one manageable location with control and precision and with a DOR that is less than that needed for surface applications.

Subsea dispersant injection also provides a human health protection factor. It reduces the need for surface recovery, in-situ burning, and surface dispersant operations, thereby reducing the potential for accidents during these operations. In addition , the importance of maintaining a safe source control environmental for workers operating above the oil release site is paramount to an effective response. Use of subsea dispersant injection (SSDI) can substantially reduce surface volatile organic compounds (VOCs) and reduce the likelihood of exceeding the Lower Explosive Limits. Consequently, it is an important tool that helps to safely sustain well-capping and source containment operations during a blow-out situation.

Logistics: Subsea dispersant injection requires additional deployment time to initiate as compared to an aerial application. Vessels equipped with remote operated vehicles (ROVs) must be deployed to the well location for installation and operation of the subsea dispersant injection system. A dispersant manifold (subsea dispersant distribution panel) needs to be positioned on the supply vessel, and coiled tubing is then deployed to the seafloor using the vessel's crane and placed into position by the ROV. If a Cap and Containment system has already been installed on the well head, it is possible to inject dispersant directly through an injection port on the capping stack, or via an ROV-held application wand positioned outside of the capping stack . Given the substantial distance from shore, it is anticipated that the specialized equipment would take approximately seven to ten days to be mobilized and set up at the source control location. Once deployed and connected, the system is designed to operate continuously via remote monitoring. It should be noted that the subsea dispersant injection approval process may also require a subsea dispersant monitoring plan to be implemented, so logistics consideration should be given to mobilizing scientific teams and equipment for this purpose. The reader is referred to the 2013 API Technical Report 1152, "Industry Recommended Subsea Dispersant Monitoring Plan – Version 1.0" (available for download at http://www.oilspillprevention.org/) for more information on water quality monitoring objectives.

Limitations: Unlike most other response options, which are limited to daylight hours for aviation and vessel safety reasons, subsea dispersant injection can virtually be maintained 24-hours per day, seven days per week, provided that required dispersant volumes can be supplied to the site . A disruption to the dispersant stockpile would likely only occur during extreme weather events when dispersant tote transfers could not be conducted , or when ROV support vessels were recalled to port due to safety considerations. Safety limitations can vary from vessel to vessel and are set at the discretion of the vessel's Captain and the Incident Command Safety Officer. It is important to note that high seas caused by extreme weather events will result in natural dispersion of oil at the surface, so dispersion will still be occurring. It should be noted that an approval process may also require a subsea dispersant monitoring plan to be implemented.

Efficiency: Results from laboratory testing on similar crude oils have indicated that effectiveness may approach 100% if proper injection methods and DORs are used. While DOR of 1:20 is usually used for surface dispersant application, ratios as low as 1:50 to 1:100 can be used subsea with a high efficiency. This is due to the fact that dispersants are delivered directly into the oil stream exiting the well where oil is fresh, not emulsified, warm (low viscosity), and in a region of high turbulence. For the purposes of this scenario and NEBA, subsea dispersant 'application efficiency' was assumed at 80% as a modelling assumption. It means that 20% of dispersant is lost and the remaining dispersant treats the oil with 100% efficiency. This conservative assumption allows for the evaluation of the maximum amount of oil that may enter the water column and resulting environmental impacts. Effectiveness for subsea dispersant injection can be qualitatively assessed by t rained observers looking at real -time video feeds provided by ROV video cameras that are positioned adjacent to the dispersant injection wand . Droplet size analysis by means of a particle size analyzer located just above the dispersant injection point could provide quantitative confi rmation of effective dispersion by confirming that the droplet size is being reduced. It should be noted however, that it may not always be feasible to place an instrumentation package just above the well bore as it may interfere with other critical Source Control response activities geared towards capping the well. Subsea dispersant effectiveness can also be assessed by comparing the surface expression (after the oil has risen to the surface) when left untreated, compared to the surface expression of the oil slick once dispersants have been applied subsea. Since it takes time for the oil to rise to the surface from the sea floor release point, there will be a delay in any changes to surface expression of the slick. Slick size can be assessed either by aerial spotting teams or via satelli te or other remote imagery devices.

2.4 Spill Modelling

2.4.1 Background and Approach

A combination of stochastic and deterministic modelling approaches were used to estimate both near and far field fate and effects of oil from unmitigated subsea release scenarios (Horn and French McCay 2014a). These same subsea blowout scenarios were then considered and assessed with surface and subsea dispersant application in a separate modelling report (Horn and French McCay 2014b) . A thorough description, and detailed modelling results are available in *Trajectory Modelling in Support of the Shelburne Basin Exploration Drilling Program: Model Description, Approach, and Summary of Results,* and the subsequent *Analysis of Subsurface and Surface Dispersant Application* (Horn and French McCay 2014a and b) reports. Note that this first modelling report (Horn and French McCay 2014a) is provided as Appendix G in the EIS (Stantec 2014a) . The dispersant modelling report (Horn and French McCay 2014b) is available upon request.

Stochastic mode lling, which was conducted in the initi al trajectory mode lling report, is comprised of numerous individual trajectories at each site (i.e., 480 trajectories) of the same spill scenario , released under varying conditions such as weather and s ea state , to produce probabilistic distributions of the released oil for the unmitigated release scenarios considered . Stochastic analys es are used to provide information regarding probability of areas to be affected, as well as the shortest time frame for the oil to reach any of the predicted areas. This modelling represents an important tool in spill response planning, as it provides an understanding of where the oil could go and what its characteristics may be over the course of an incident. The results of the stochastic modelling illustrate the full potential spatial extent of oil and the potentially impacted areas. However, it is important to note that the potentially affected

areas do not indicate distribution of oil from any single release, but instead demonstrate generally where the oil could go, based upon environmental variability. While such maps do not provide information on the quantity of oil in a given area, they denote the probability of oil exceeding a given threshold, even if this threshold was exceeded for as short as 15 minutes. Additionally, stochastic maps (not shown in the body of this report) showing areas affected by total petroleum hydrocarbons (TPH) and dissolved aromatics depict oiling frequency, but do not indicate the specific depth at which this occurs, or imply that the entire water column will experience a concentration above a threshold (Horn and French McCay 2014a).

Deterministic modelling was performed in addition to stochastic modelling for this study. Horn and French McCay (2014a) write: "While the stochastic analysis provides insight into the probable behavior of oil spills given historic wind and current data for the region, it does not provide an individual trajectory, oil weathering information, expected concentrations and thickness of oil contamination, mass balance, and other information related to a single spill at a given location time." Deterministic modelling uses single runs to help provide some of this additional information.

The model thresholds used for the trajectory modelling studies are provided in Table 6. Trajectory modelling was performed to assess the behaviour and fate of dispersed oil following the surface and subsea dispersant applications. Subsea and surface dispersant applications will result in changes in oil distribution within the environment including the deep water column, surface mixing layer, water surface, and the atmosphere. Even without dispersant injection, a certain amount of water column entrainment will occur, and will vary with the oil type, release conditions, and plume turbulence. Entrained oil typically remains within depth boundaries that are based on density. Oil that is not entrained will rise to the surface, where surface slicks will form. Nearly half the oil volume released under modelled conditions (with no dispersant addition) may be expected to become naturally dispersed in the water column.

The addition of dispersant is intended to reduce oil droplet sizes, increase the amount of oil that becomes entrained in the water column, and reduce the amount of oil that surfaces. Any resurfacing oil would form slicks that are smaller in the area, thinner, patchier and less persistent than they would be in unmitigated case. Reduction of surface oil slicks also reduces the amount of oil lost through evaporation to the atmosphere. To support the subsea dispersant modelling, a range of subsea dispersant treatment scenarios were simulated for each spill site to identify the optimum DOR, using the minimum volume of dispersant, resulting in the largest amount of oil in the water column. The identified DOR for each site was then applied to the individual model runs conducted as part of the dispersant modelling report (Horn and French McCay 2014b). The potential effects of dispersant use on the previously modelled spill scenarios were also modelled in a separate report (Horn and French McCay 2014b).

Scenarios considered in the dispersant application modelling report included the 50th percentile and the 95th percentile surface oiling scenarios for Sites 1 and 2 from the main trajectory modelling report (Horn and French McCay 2014a). These 50th and 95th percentile scenarios are representative deterministic cases that were identified from stochastic analyses (480 runs per site; 240 by summer/winter season). The 50th percentile case was chosen to illustrate average/typical environmental conditions resulting in median surface oiling and to put the 95th percentile case into context. The 95th percentile case was identified as having some of the largest areas of ocean surface affected by spilled oil and thus a

conservative basis to consider dispersant application and potential environmental consequences. The 95th percentile surface oiling scenario occurred during the summer season (April through September) as warmer and more quiescent summer conditions resulted in increased surface oil by both mass and area covered, as compar ed to winter conditions. The areas affected were defined as the surface area of ocean experiencing surface oil thicknesses in excess of 0.04 µm for at least 15 minutes. Models were run for each scenario for a period of 30 days to reflect the maximum time e xpected to cap and contain the well.

Table 6. Modelled Thresholds (Horn and French McCay 2014b)

Oil Type	Oil Thickness / Concentration Cut-off Threshold	Rationale
Surface Oil Thickness	0.04 µm	Visible threshold used to determine impacts on socioeconomic resources (e.g., possibility of fisheries closure). This minimum thickness would relate to a slick being barely visible as a colourless or silver sheen (French-McCay *et al.*, 2011; Lewis, 2007 – Bonn Agreement).
	10 µm	Biological threshold for ecological impacts to the water surface (e.g., birds) (French *et al.*, 1996 & French-McCay 2009 oil spill fate and effects model). Oil would appear as a dark brown colour.
Shoreline Oil Mass	1.0 g/m^2	This thickness is the threshold for potential effects on socio-economic resource uses, as this amount of oil would conservatively trigger the need for shoreline cleanup on amenity beaches. Oil would appear as a dull brown sheen (French-McCay *et al.*, 2011).
	10.0 g/m^2	This thickness provides a more conservative screening threshold for potential ecological effects to shoreline habitats, which has typically been 100 g/m^2, based upon a synthesis of the literature showing that shoreline life has been affected by this degree of oiling (French *et al.*, 1996; French McCay 2009). The oil would appear as dark brown coat or opaque/black oil.
In Water Concentration	1.0 ppb of dissolved aromatics	Exposure concentration below which no noteworthy biological effects are expected for sensitive marine resources (Trudel, 1989 and French-McCay, 2004) in S.L. Ross 2011 modelling for Old Harry in Gulf of St. Lawrence). This value is a conservative threshold for early contact on herring larvae.
	1 ppm TPH	Exposure concentration deemed a low level of concern for sensitive life stages in marine organisms (Kraly *et al.*, 2001; NAS NRC 2005). This conservative approximation is at the low end of lethal and sub-lethal impacts expected from acute exposure.

	15 ppm TPH	Canada-Nova Scotia Offshore Petroleum Board – Offshore Waste Treatment Guidelines (CNSOPB OWTG 2010) performance target for TPH in deck drainage / bilge water discharged at sea.
	30 ppm TPH	Canada-Nova Scotia Offshore Petroleum Board – Offshore Waste Treatment Guidelines (CNSOPB OWTG 2010) 30 day weighted average performance target for TPH in produced water discharged to sea.

The hydrocarbon trajectories produced provided a history of modelled oil in time and space. Components of the oil were tracked as entrained droplets of oil, dissolved aromatic constituents, floating surface oil, and stranded shoreline oil. In addition to the trajectories, supporting information and figures related to the fate and effects were provided in the reports including:

1. Mass Balance – The mass balance charts provide an estimate of the oil's weathering and fate for a specific run for the entire model duration as a fraction of the oil spilled up to that point. Components of the oil tracked over time include the amount of oil on the sea surface, the total entrained or dissolved hydrocarbons in the water column, amount of oil ashore, oil evaporated into the atmosphere, and that which has decayed (accounts for both photo -oxidation and biodegradation).
2. Surface Oil Time Series Maps – Maps showing the cumulative footprint of maximum floating surface oil and the associated thicknesses (µm) at all time steps during the individual 30-day spill simulation. Surface oil figures show only thicknesses greater than 0.04 µm.
3. Water Column Time Series Maps – Maps showing the cumulative footprint of maximum water column concentration of dissolved aromatics (ppb) at all time steps during the individual 30 -day spill simulation. Dissolved arom atics are the portion of the oil having the greatest potential to affect water column biota, and the footprints were typically smaller than the extent of total oil contamination in the water column. Water column contamination figures show only concentrations ≥1 ppb. Concentrations below 1 ppb are considered low and result in little water column impact.
4. Shoreline Impact - Figure showing mass of oil deposited onto shoreline. Only shoreline oiling exceeding 1 µm, which is equivalent to 1 g/m^2, was depicted.
5. Additional maps were created to illustrate extent of a slick at 0.5, 1, 2, 5, 10, 15 and 30 days, maximum water column TPH concentrations exceeding 1 ppm over 30 days as well as vertical profiles illustrating distribution of hydrocarbons in the water column.

2.4.2 Modelling Results

In general, the modelling studies used in this NEBA (Horn and French McCay 2014a) predicted low likelihood of shoreline oiling (less than 2% chance). The modelling for Sites 1 and 2 resulted in shoreline oiling in 9 out of 480 scen arios and 4 out of 480 scenarios respectively. All shoreline oiling cases occurred during the summer season, limited to the months of May, June, and July, where more quiescent conditions result in a higher percentage of oil remaining on the water surface (Horn and French McCay 2014a). In scenarios where shoreline oiling was shown to occur from an unmitigated blowout scenario, it is expected that the stranded oil would be highly weathered, as the minimum time to shore would be between 20-30 days. The regions shown to be susceptible to potential shoreline oiling

within 30 days from an unmitigated release at Site 1 include the southern tip of Nova Scotia, including Yarmouth, Barrington and Shelburne region, as well as Sable Island National Park Reserve. The reg ion susceptible to potential shoreline oiling within 30 days from an unmitigated release at Site 2 includes only Sable Island National Park Reserve (Stantec 2014a; Horn and French McCay 2014a). Figure 8 illustrates the unmitigated modelling results of the 50 th and 95 th percentile scenarios for predicted oil distributions over the entire 30 day period (cumulative) for Sites 1 and 2.

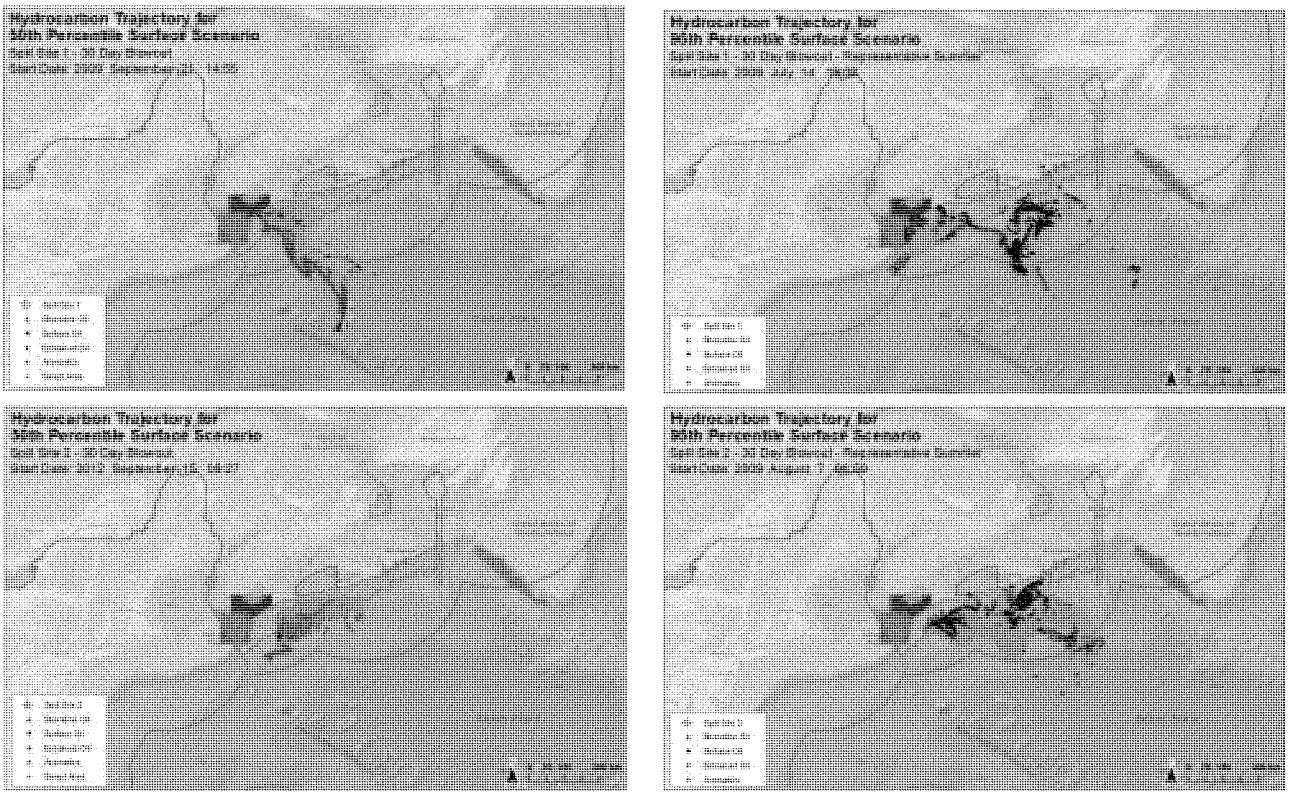

Figure 8. Unmitigated Releases for Sites 1 (top 2 panels) and 2 (bottom two panels) for 50th (panels on the left) and 95th (panels on the right) percentile scenarios (Horn and French McKay 2014b). Refer to Figure 4 for identification of spatial boundaries.

It is important to note that these figures represent the cumulative distribution of all areas affected by oil at any time during the 30 day period . They illustrate a single oil spill over the full 30 days modelled . The 95th percentile unmitigated release results in more oiling on the surface (shown in black), when compared to the dispersant mediated scenario. Darker shades represent oil that was present at the end of the 30 day period (the last time step), while lighter shades cover the "swept area", where oil occurred at some time during the 30 day period.

Figures 9 and 10 suggest that less surface oil and more entrained oil is likely when dispersants are applied at both sites.

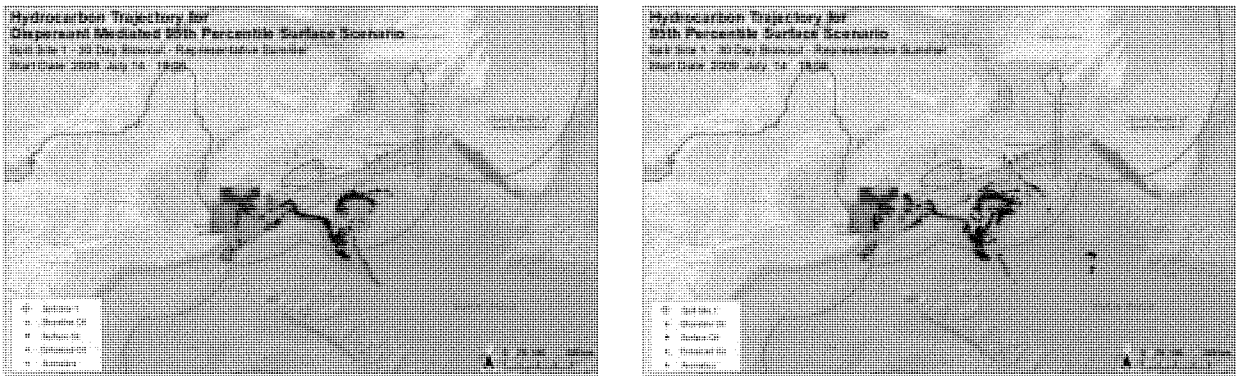

Figure 9. Hydrocarbon trajectories for dispersant mediated (left) vs. unmitigated releases (right) for the 95th percentile surface scenario at Site 1 (Horn and French McCay 2014b). Refer to Figure 4 for identification of spatial boundaries.

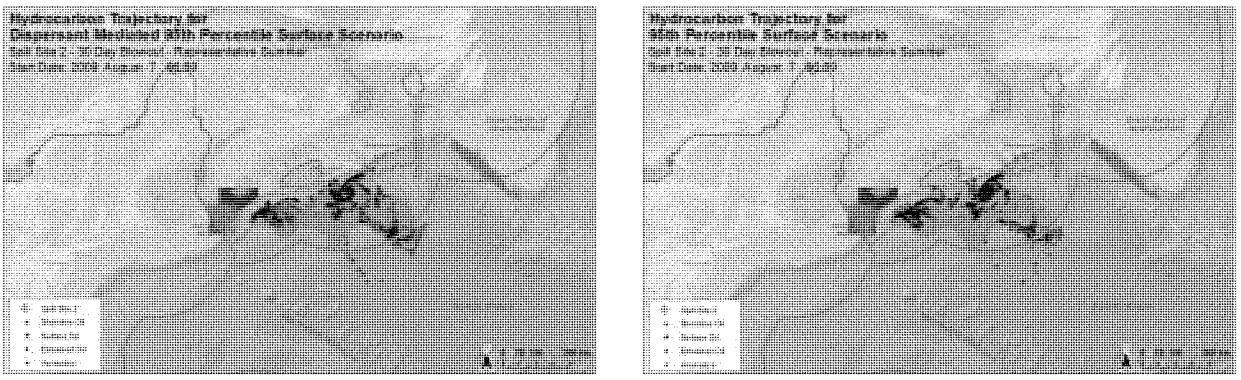

Figure 10. Hydrocarbon trajectories for dispersant mediated (left) vs. unmitigated releases (right) for the 95th percentile surface scenario at Site 2 (Horn and Fr ench McCay 2014b). Refer to Figure 4 for identification of spatial boundaries.

In comparison to the cumulative model results shown and described above, which illustrated all areas affected by oil over the entire 30 day period, model results for individual time snapshots throughout the 30 days yielded much smaller oil spill footprints as they show an actual location of a specific slick at each selected point in time. Figure 11 displays results for Day 5 at Site 1 , for both the dispersant mediated scenario (left) , where all oil is entrained, and the unmitigated scenario (right) , where s urface oil is observed.

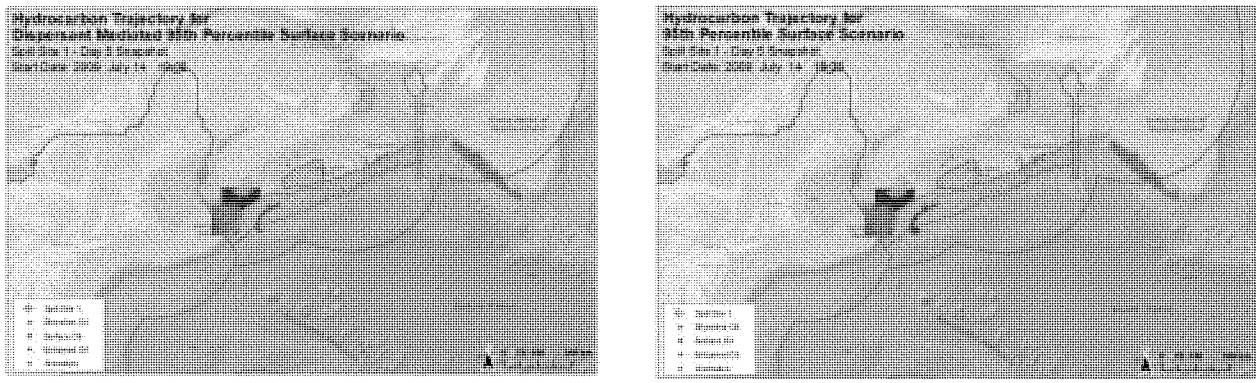

Figure 11. Hydrocarbon particle trajectories predicted for Day 5 of a subsea blowout in the summer season (July) at Site 1 with subsea dispersant application (left) and without (right). (Horn and French McCay 2014b). Refer to Figure 4 for identification of spatial boundaries.

Although the spill footprin t shown in the maps in Figure 11 is much smaller than those shown in the cumulative maps in Figure s 9 and 10, the effect of subsea dispersant application remains the same (reduction in surface hydrocarbons and aromatics, and a corresponding increase in entrained oil).

Mass Balance calculations were also performed for both the unmitigated and dispersant mediated scenarios shown above. For example, Figure 12 shows the resulting ma ss balances and illustrates the effect of subsea dispersant application (shown on the left) versus the unmitigated release (shown on the right) on the distribution of oil into the environment at Site 1. Fate categories shown include: Atmosphere (dark blue) ; shoreline (maroon); surface (green); entrained (purple), and biologically degraded, or "decayed" (light blue). A much smaller percentage of the oil is present on the sea surface in the dispersant mitigated case, compared to the unmitigated scenario.

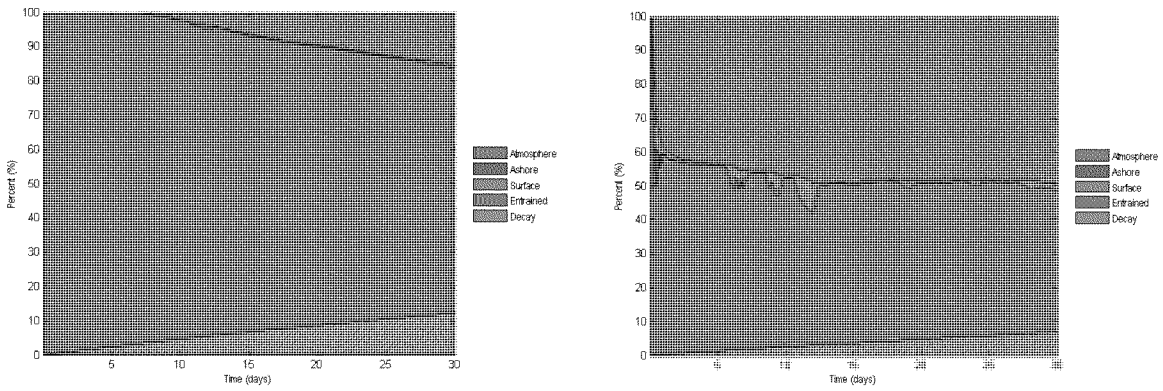

Figure 12. Impact of subsea dispersant injection on mass balance of oil at Site 1 (Horn and French McCay 2014b).

Subsea dispersant application resulted in a much larger portion of the spilled oil being entrained in the water column (75% for Site 1) when compared to unmitigated cases (40% for Site 1). As a result the volume of water experiencing total petroleum hydrocarbon (TPH) concentrations exceeding 15 and 30 ppm were 3 to 6 and 30 to 60 times greater, r espectively. It is important to note that with subsea dispersant application, this entrained oil tended to remain at depth (>1000 m), when compared to the unmitigated scenario. A s a result , a smaller volume of water was observed to experience dissolved aromatic concentrations exceeding 1 ppb than with the unmitigated case . Additionally, the dispersant mediated scenarios showed a sizeable reduction in surface oil (12%) by mass as well as a reduction in evaporated oil (35 to 40%) lost to the atmosphere when compared to u nmitigated scenarios. This reduction in volatile oil components released to the atmosphere results in a reduced risk and threat to the health and safety of response personnel working near the spill source (i.e., lower VOC concentrations). Surface oiling fo otprints in dispersant-mediated scenarios took longer to appear, were smaller in area, and less continuous when compared to unmitigated releases (Horn and French McCay, 2014b).

Each of the figures presented above depict oil distributions across the various modelled parameters (i.e., shoreline, surface, entrai ned, and dissolved aromatics). The effect of subsea dispersant application on hydrocarbon distributions in the water column can be seen more clearly when these parameters are examined individually. Figures 13 and 14 illustrate the effect of subs ea dispersant application (left) on water column TPH concentrations in the droplet phase as compared to the unmitigated scenario (right) for Sites 1 and 2.

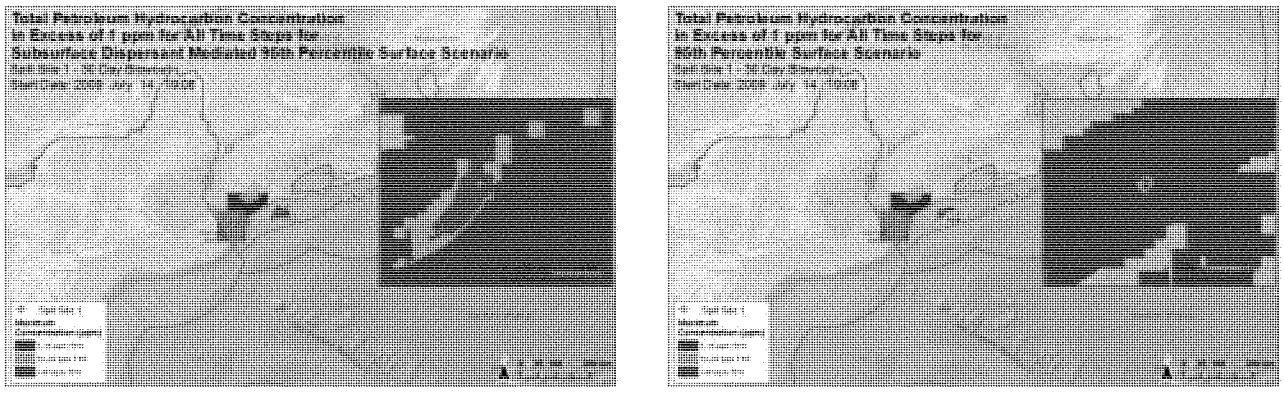

Figure 13. Impact of subsea dispersant injection (left image) versus unmitigated release (right image) on TPH maximum concentrations at Site 1 (Horn and French McCay 2014b). Refer to Figure 4 for identification of spatial boundaries.

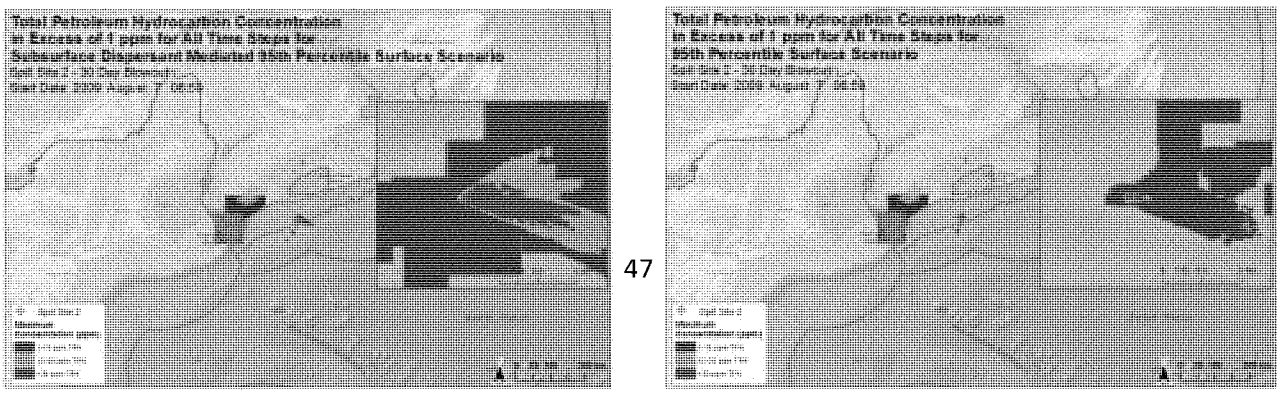

Figure 14. Impact of subsea dispersant injection on TPH distribution at Site 2 (Horn and French McCay 2014b). Refer to Figure 4 for identification of spatial boundaries.

The areas or volumes that experienced oiling above the established thresholds for unmitigated releases, surface dispersant treatment, and subsea dispersant treatment are presented in Table 7. The use of subsea dispersant reduces the area of exceedance for each surface thickness threshold by approximately 4 to 50 times. Similarly, the use of dispersant at the surface reduces surface slicks by over 20% under optimal weather conditions and daylight hours.

Subsea dispersant-mediated trajectory model results indicate that the application of subsea dispersants will result in a larger fraction of oil becoming entrained in the water column and a reduced amount of oil reaching the surface. Subsea dispersant application resulted in smaller surface oiling footprints that took longer to appear, were smaller in area, and less continuous (more dispersed), when compared to untreated releases. Approximately 75% of the spilled oil remained in the water column for the subsea dispersant-mediated case at Site 1, relative to the predicted approximate 40% in the unmitigated release for the same site. Nearly 80% of the dispersant-mediated Site 2 release remained in the water column, relative to ~45% for the same, unmitigated release.

Smaller differences were observed in mass balance for surface dispersant application scenarios, with a 2-5% reduction in surface oil, and corresponding gain in the water column. This relatively smaller impact may be the result of naturally high sea states and resulting high levels of physical oil dispersion at the surface in the unmitigated case. The data provided by Horn and French McCay (2014b) suggests that for both surface and subsea dispersant treatments, surface slicks were thinner, patchier, and less persistent than for untreated slicks.

As more oil remains entrained in the water column and less oil surfaces, evaporative loss at the surface decreases. Only 10-15% of the total oil was observed to evaporate in the subsea dispersant mediated scenarios, relative to nearly 50% observed in the unmitigated cases. TPH values above 1 ppm may occur out to roughly 50-100 km from the release location in 30 day release scenarios. Concentrations of dissolved aromatic hydrocarbons may exceed 500 ppb (0.5 ppm total petroleum hydrocarbons) in patches within the vicinity (~75 km) of the release location, at localized depths between roughly 1000-2000 m depth. However, much lower concentrations (roughly 5-50 ppb) would be more common throughout the affected area.

As hydrodynamic forcing (e.g., currents, winds, etc.) was the same between cases, the areal footprints were very similar between dispersant-mediated and unmitigated releases. However, as indicated, for both subsurface and subsea dispersant treatments, surface slicks were thinner, patchier and less persistent than for untreated areas.

Table 7. Threshold Exceedances for Modelled Scenarios: Site 1

SITE 1	Exceedance Region	Area / Volume Exceeding Thresholds
Unmitigated Subsurface Release (30 day scenario)	Surface Oil Thickness	0.04 µm = 75,300 km^2 10 µm = 2,300 km^2 50 µm = 400 km^2
	In Water Concentration	1 ppb dissolved aromatics = 3.5×10^{14} m^3 1 ppm TPH = 7.2×10^{13} m^3 15 ppm TPH = 1.7×10^{12} m^3 30 ppm TPH = 8.6×10^{10} m^3
Subsurface Dispersant Application (30 day scenario)	Surface Oil Thickness	0.04 µm = 19,300 km^2 10 µm = 300 km^2 50 µm = <10 km^2
	In Water Concentration	1 ppb dissolved aromatics = 1.1×10^{14} m^3 1 ppm TPH = 3.9×10^{13} m^3 15 ppm TPH = 1.1×10^{13} m^3 30 ppm TPH = 4.8×10^{12} m^3
Unmitigated Subsurface Release (4 day scenario)	Surface Oil Thickness	0.04 µm = 740 km^2 10 µm = 60 km^2 50 µm = <10 km^2
	In Water Concentration	1 ppb dissolved aromatics = 3.5×10^{14} m^3 1 ppm TPH = 4.6×10^{12} m^3 15 ppm TPH = 1.2×10^{11} m^3 30 ppm TPH = 3.4×10^{10} m^3
Surface Dispersant Application (4 day scenario)	Surface Oil Thickness	0.04 µm = 650 km^2 10 µm = 60 km^2 50 µm = <10 km^2
	In Water Concentration	1 ppb dissolved aromatics = 4.6×10^{12} m^3 1 ppm TPH = 2.0×10^{12} m^3 15 ppm TPH = 1.4×10^{11} m^3 30 ppm TPH = 3.4×10^{10} m^3

Table 8. Threshold Exceedances for Modelled Scenarios: Site 2

SITE 2	Exceedance Region	Area / Volume Exceeding Thresholds
Unmitigated Subsurface Release (30 day scenario)	Surface Oil Thickness	0.04 µm = 83,500 km^2 10 µm = 7,300 km^2 50 µm = 500 km^2
	In Water Concentration	1 ppb dissolved aromatics = 3.9×10^{14} m^3 1 ppm TPH = 1.1×10^{14} m^3 15 ppm TPH = 3.3×10^{12} m^3 30 ppm TPH = 5.2×10^{10} m^3
Subsurface Dispersant Application (30 day scenario)	Surface Oil Thickness	0.04 µm = 21,400 km^2 10 µm = <10 km^2 50 µm = <10 km^2
	In Water Concentration	1 ppb dissolved aromatics = 2.5×10^{14} m^3 1 ppm TPH = 1.1×10^{14} m^3 15 ppm TPH = 1.1×10^{13} m^3 30 ppm TPH = 1.4×10^{12} m^3
Unmitigated Subsurface Release (4 day scenario)	Surface Oil Thickness	0.04 µm = 910 km^2 10 µm = 80 km^2 50 µm = <10 km^2
	In Water Concentration	1 ppb dissolved aromatics = 6.1×10^{12} m^3 1 ppm TPH = 3.9×10^{12} m^3 15 ppm TPH = <2.5×10^{10} m^3 30 ppm TPH = <1.5×10^{10} m^3
Surface Dispersant Application (4 day scenario)	Surface Oil Thickness	0.04 µm = 720 km^2 10 µm = 60 km^2 50 µm = <10 km^2
	In Water Concentration	1 ppb dissolved aromatics = 6.2×10^{12} m^3 1 ppm TPH = 4.0×10^{12} m^3 15 ppm TPH = <2.5×10^{10} m^3 30 ppm TPH = <1.5×10^{10} m^3

Surface dispersant application increased the entrainment of surface oil into the upper, mixed layer of the water column, within roughly 1 km of the wellhead, with concentrations exceeding 1 ppm out to 5 - 10 km in these 4 -day release scenarios. Similarly, concentrations of dissolved aromatics exceeded 500 ppb in small patches within the vicinity (<10 km) of the release location throughout the surface layer (<50-100 m depth). However, much lower concentrations (roughly 5- 50 ppb) would be more common throughout the affected area.

The timing of surface dispersant application had a large e ffect on the mass balance of surface oil, and maximum differences in mass balance occurred during the daytime, a nd periods of lower sea states. Oil accumulated on the surface at night, when dispersants were not applied.

No shoreline oiling was observed in any of the dispersant mediated or unmitigated release trajectories run in association with the dispersant modelling report and used to support the NEBA.

2.4.3 Conclusions from Modelling

In summary, the use of subsea dispersants reduces the area exceeding surface thickness thresholds by over 75%, when compared to unmitigated cases. Similarly, the targeted use of dispersants at the surface may reduce areal coverage of surface oil by 10 -20% in the first few days of the release. Dispersing oil into water column results in an increase in the region of potential oil exposure for marine organisms , although exposure concentrations are expected to be relatively small in most of the areas . Higher concentrations of dissolved aro matics and total TPH were found in the upper water column in unmitigated cases, while they were typically found at localized depths between roughly 1000 -2000 m in the subsea dispersant application cases.

Unmitigated release scenarios resulted in the largest footprints for surface oil exceeding 0.04 µm thickness, with 3-4 times more coverage when compared to the subsea dispersant application scenarios. The biological thresholds of 10 and 50 µm surface oil w ere 2-4 orders of magnitude lower, by area, than the highly conservative 0.04 µm threshold representing the first appearance of a barely visible sheen.

The application of subsea dispersant results in roughly 25% the area of surface oil thickness exceeding 0.04 µm and approximately 10% or less exceeding 10 and 50 µm, when compared to unmitigated scenarios. However, subsea dispersant treatment resulted in water column hydrocarbon concentrations 1-2 orders of magnitude higher (e.g. , exceeding 15 and 30 ppm TP H than observed for unmitigated release scenarios).

The smallest extent observed for surface oiling occurred in the surface dispersant scenarios. This was due to the shorter period model led (limited to 4 days), the effects of the dispersant, and weather conditions conducive to physical dispersion.

Evaporative loss of oil components to the atmosphe re was considerably reduced by surface and subsea dispersant application. While protection of human health and safety was not a specific focus of this study, the potential reduction in exposure to hyd rocarbons could have important benefits to first responders and emergency response operations.

3 The Risk Analysis Process

3.1 The Risks Associated with Oil Exposure

The Shelburne Basin Venture Exploration Drilling Project Environmental Impact Statement (Stantec 2014a), provides a detailed overview of the existing biological environment as well as the effects of hydrocarbons to various species. Section 5 of the EIS provides an overview of the existing environment and Section 8 provides a thorough review of the impacts of untreated oil to marine and avian species. In summary, surface oil poses a variety of risks to birds, marine mammals and other species utilizing the top layer of the ocean surface to live, feed, rest, and breathe. Surface oil can saturate feathers and fur which can reduce the ability of animals to thermo-regulate, which can often result in death if not treated immediately with veterinary care. In cases where these animals escape direct lethal exposure, pelagic and coastal seabirds and marine mammals can sustain sub-lethal damages such as skin, eye and respiratory irritation from exposure to surface oil. The sea surface microlayer also serves as an important habit for many fish species eggs and larvae, which are sensitive to oil.

Once oil is spilled into the water and spreads over the surface, a number of physical, chemical and biological processes immediately begin to alter the oil's characteristics which may prohibit the effectiveness of some response options. If untreated, the surface oil will begin to weather over time, and processes such as evaporation, spreading, and emulsification will cause the oil to form a "mousse" and eventually tar balls. A mousse in this context is a water-in-oil emulsion that is resistant to dispersant effects and difficult to burn or recover with skimmers. Emulsified oil may persist for a long time serving as a continuous source of contamination to the top portion of the water column. Consequently, the weathering process necessitates a rapid response to mitigate a spill.

Chemical interactions between the atmosphere and the slick can cause the formation of gaseous vapours, and the oil chemistry can be further altered by sunlight. Aerosols may be formed when high wind and wave conditions beat water through the oil slick. These dynamic processes as well as oil persisting on the surface increases the risk of exposure to birds, marine mammals, and human receptors in the area.

Chemical processes assisted by wave action and current mixing are also underway beneath the surface of an oil slick. These natural processes drive bulk oil and soluble constituents into the water column, increasing exposure to marine life. It is important to consider that a portion of the oil will be present in the water column in dissolved and dispersed form even if dispersants are not used. Natural oil entrainment is especially likely for light oils, deep water blowouts, and high sea conditions. Oil weathering processes also cause the viscosity of the oil to increase, initially making it more difficult to disperse, and eventually making it more difficult to retain and recover with mechanical equipment, or to burn in place. These weathering dynamics put further pressure on responders to make a timely decision about deploying the appropriate mix of response options. Waiting too long to make a decision limits the response tools that will work. A decision to use aerial dispersants must be made in a timely manner, since dispersants are most effective in the first few days before the oil becomes more highly weathered,

In the case of an oil spill from a subsea blowout, the same physical and chemical processes as those in a surface spill influence the environmental fate of the oil, but to different degrees. Oil released under pressure at the sea floor tends to rise due to the buoyancy of the droplets. The oil rises in liquid droplets

of varying size, and the droplets that reach the surface coalesce, forming an oil slick that is subject to the weathering processes for a surface oil spill. However, the subsea spill's travel through the water column can affect the oil, as the gas components will quickly dissolve in to the water column. The smallest oil droplets may be trapped at lower depths, as their buoyancy cannot overcome the horizontal forces in the water column. Their small size however, increases the likelihood that they will be broken down through biodegradation processes. Conversely, larger droplets will continue to rise and will lose their soluble oil components through dissolution during the ascent. Currents mix and spread these droplets in the water column, complicating the formation of an intact oil slick, and increasing the likelihood that the oil will surface in a weathered state, perhaps appearing as a mousse.

These processes have their largest impact within the initial hours of release, and these challenges are the basis for development of methods for injecting dispersants directly into the subsea oil release. Subsea injection of dispersants during a response can greatly increase the percentage of oil that is entrained in the water column as small droplets, thereby preventing the formation of large surface slicks, and facilitating the biodegradation process.

The toxicity of dispersants and dispersed oil has been a source of controversy and misunderstandings since dispersants were first used. Modern day dispersant products (e.g., Corexit 9500, Finasol OSR52, and Dasic Slickgone) have very low toxicity. In fact, Corexit 9500 is classified as only "slightly toxic" according to the EPA Toxicity Guide (US Environmental Protection Agency, 2014). Studies conducted by the EPA during the DWH spill in 2010 reported results of Corexit 9500 toxicity to several species as being "practically non-toxic" Guide (US Environmental Protection Agency, 2010). As a result the real issue for dispersant use is the toxicity of the dispersed oil (National Research Council, 2005).

Before addressing the topic of dispersed oil toxicity, it is helpful to acknowledge that any of the spill scenarios in which dispersant application would be considered as a response option already represent some degree of marine toxicity risk due to the toxicity of the oil itself. Studies also indicate that with dispersed oil, any toxicity of the oil dispersant mix results primarily from the oil and not the dispersant. This is because unmitigated floating slicks pose significant toxicity risk via physical coating of marine mammals and birds, especially to those species which feed or rest on the waters' surface. Additionally, natural dispersion of untreated surface oil is expected in this Project area when higher sea states are present (refer to trajectory models), so there will be elevated hydrocarbon concentrations present even if dispersants are not applied. For these reasons, the decision to use dispersants is based on the assessment of the risks posed by dispersed oil, as compared to the risks of not dispersing the oil.

The toxicity of dispersed oil in the water column is related to three factors:

1. Whether the concentration exceeds known acute or chronic toxicity thresholds for the oil type that was spilled;
2. The length of time that the concentrations persist above toxic thresholds; and,
3. The toxicological sensitivity of the species exposed to oil above the acute or chronic toxicity thresholds.

The ability of habitats and populations to recover after initial impact is also an important consideration. There is a wide range of sensitivity among species, and at different life stages of the same species. It is

important to identify the species living in the area that will be treated with dispersants, and the life stages they are in order to make sound decisions, based on local environmental conditions.

Controlled studies have shown:

- The most notable environmental impact considerations for dispersed oil exposures occur in the water column; and
- Sediments on the seafloor rarely have accumulations of chemically dispersed oil at levels that pose environmental concerns (see text box in Section 2.3.2).

As previously mentioned, marine toxicity is a function of exposure — which includes the concentration of dispersed oil in the water column for a specific duration — and the sensitivity of the marine species present in the environment. Figure 15 illustrates a high level summary of many data points from standard laboratory toxicity tests . From a review of toxicity databases (NRC, 2005; DTox, 2014), "more sensitive species" are defined as those laboratory tested species (or life stages) that were lethally affected (LC50) in the 1 -10 ppm dispersed oil range. "Less sensitive species" are identified as those laboratory tested species (or life stages) that were lethally affected (LC50) above 10 ppm d ispersed oil. The lab tests also measure short -term impairment in growth, reproduction, respiration rates, etc. — changes that may be serious to overall health but do not immediately kill a test subject. These changes are called sub -lethal effects. Previous laboratory results indicate that more sensitive species and life stages demonstrate sub-lethal effects at short duration exposures beginning at lower concentrations (0.5 ppm). As a result , when examining the expected initial concentrations of dispersed o il, it is important that both lethal and sub-lethal effects are considered.

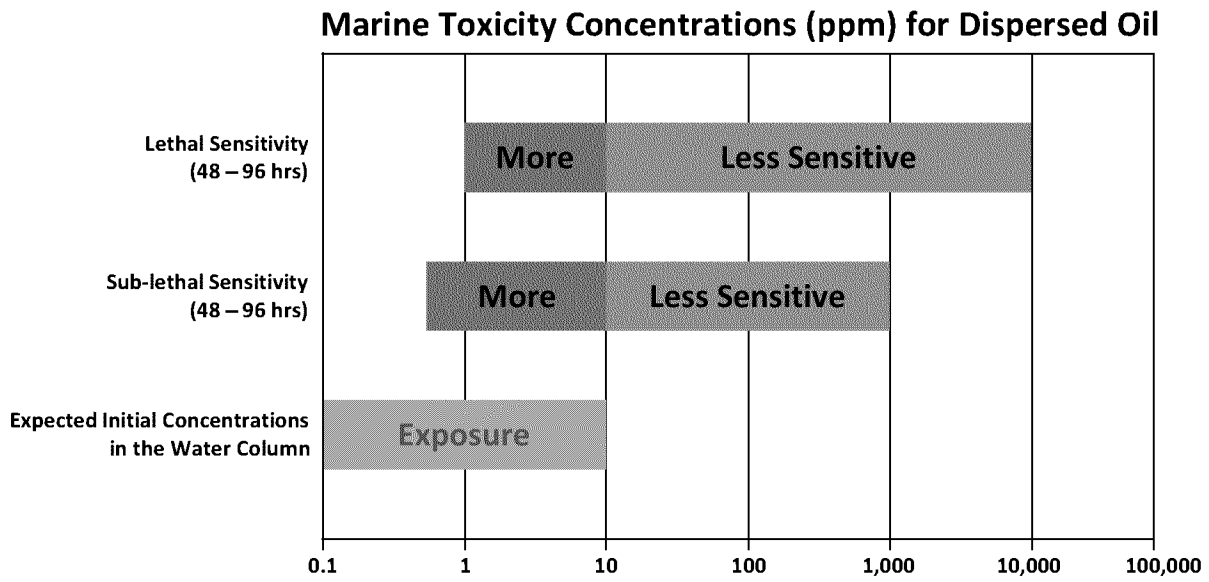

Figure 15. Species s ensitivity to dispersed oil exposures. The top row indicates typical LC50 range to organisms following an exposure duration of 48 to 96 hours. The middle row depicts sub -lethal effects

concentrations during the same time duration. The lowest bar indicates typical dissolved oil concentrations in the water following a spill. Normally, these concentrations diminish quickly (within hours) because of rapid dilution (after National Research Council, 2005)

It is important to note that using existing laboratory data to assess the potential risks to marine life from dispersed oil does not provide a full understanding of the potential effects in the ocean since the laboratory data may not accurately model exposure in the field. Some of the specific limitations of applying laboratory toxicity testing results to real-world spill response include the following (IPIECA, 2015b):

- Most standard laboratory tests are designed to report the concentrations that result in mortality of half the test organisms during a constant exposure over four days. In a real world scenario, oil that has been treated with dispersants will typically disperse, dilute and start to biodegrade in the water column in less than four days. In addition, many marine organisms are mobile and will not remain in a region with continual exposure to dispersed oil for four days. Therefore the comparison on Figure 15 may be somewhat misleading as it compares sensitivities of the organisms to constant exposure for an extended period of time with a concentration that only occurs for a short period of time (for surface application) and in a limited area.

- There are few tests using short-term exposure durations that focus on anything but lethal endpoints, so little is reported about impairments that are sub-lethal. While very useful for screening different dispersants against each other and against different oils, this laboratory data should not be used as a reliable assessment of what happens (e.g., real-world exposure concentrations, dilution, biodegradation) under dynamic field conditions.

- Lab tests routinely focus on the most sensitive species and their most sensitive life stages, and those few species that are amenable to laboratory testing conditions. Data are not available for all species and all life stages, or for all oil types.

The technical literature often involves the calculation of lethal effect concentrations based on the nominal volume of oil added and not what was actually incorporated into the water column to which the test species was exposed. Since many oil components are poorly soluble, some readily evaporate, and some stick to test system surfaces, it is difficult to compare available data that did not follow standardized testing protocols and quantify actual exposure concentrations in these tests (Coelho *et al.,* 2013).

In 2013, the NOAA-funded Coastal Response Research Center sponsored a project to rapidly assess the toxicity of physically and chemically dispersed oils. The project, known as DTox, involved the development of a dispersant and chemically dispersed oil toxicity database, and was completed in early 2014. The result is a new quantitative data compilation that provides the basis for a more thorough assessment of levels of concern for dispersants and chemically dispersed oil (Bejarano, 2014). End-users of this new tool can develop Species Sensitivity Distribution (SSD) curves that will likely improve risk estimates during oil spill response exercises or spill events by allowing the user to select data that specifically relates to particular oils or dispersants. It provides rapid access to centralized toxicity data so that data from past research can be applied in a meaningful way to current spill planning events and can aid in the threshold and risk ranking process. The reader is encouraged to view the DTox video at

http://www.researchplanning.com/wp-content/uploads/2014/02/DTox_Tutorial.mp4 to gain an understanding of the capabilities of DTox. Users can query the system to quickly access toxicity information on specific dispersants, oils, or species of interest. Further, it allows the user to directly link data in the curve to the original publication. Sample screen shots from DTox are provided in Figure 16.

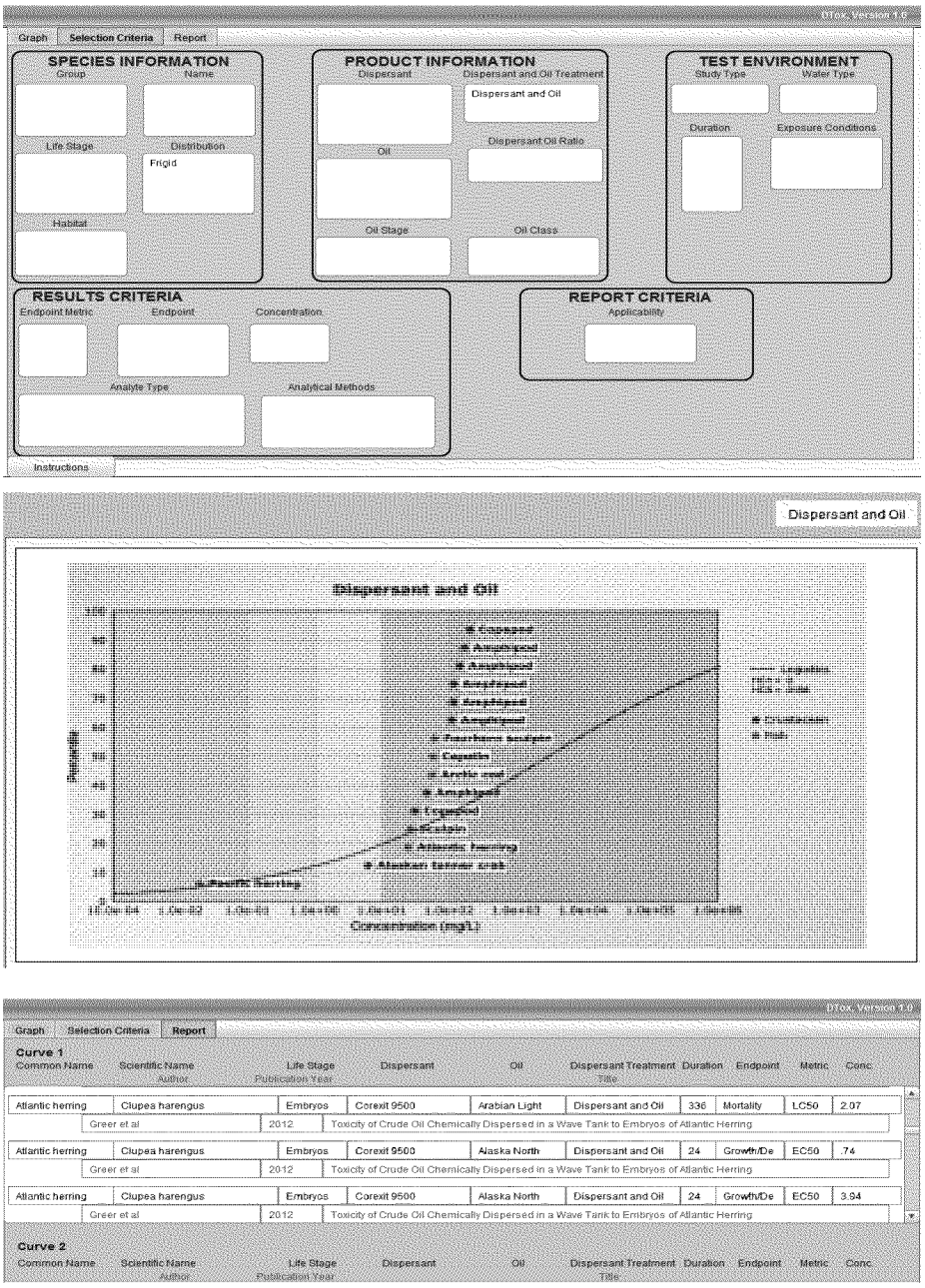

Figure 16. DTox database tool showing input query screen (top) and an example curve for some arctic species (middle). End-users can also retrieve the original source citation (bottom). (Bejarano, 2014)

The advantage to using SSD curves in lieu of conducting new species-specific testing was highlighted in a second paper by Bejarano *et al.* (2014), which concluded:

- SSDs have been shown to provide useful information of potential significance for decisions makers involved in oil spill response decision-making.
- SSDs can provide scientifically defensible benchmark values for use in dispersant use decision making and related oil spill issues, even when the SSDs are based on standard exposure regimes rather than real world, dynamic exposure tests.
- It is not necessary to continue testing new species (or extreme condition species – such as cold water) because cold water species fell within the range of sensitivities of commonly tested species, mostly of temperate climates.

It is noteworthy that the general species sensitivity brackets for dispersed oil that are identified in Figure 15, as published in the National Research Council (2005) report on dispersants, were originally derived by preparing SSD curves more than a decade ago. As new dispersed oil toxicity data has been produced since that time, there is additional evidence that many species (and life-stages) from diverse aquatic systems (from tropical to arctic) tend to respond similarly to benchmark species that have already been extensively studied.

3.2 The Risk Ranking Process

Once the risk matrix has been compiled and the resource and trajectory data evaluated, the study team used a "risk ranking matrix" in order to assign a **level of concern** to each cell in the risk matrix (Figure 17). Each axis of the risk ranking matrix represents a parameter used to describe risk: the x-axis rates duration in terms of "population recovery" and the y-axis evaluates magnitude in relation to "% of resource at risk" affected. Each cell in the risk matrix is assigned an alphanumeric value to represent relative impact. For this analysis, a 4 by 4 matrix offers sufficient resolution.

The study team divided the "population recovery" time ranges into four categories ranging from less than 1 year (rapid recovery) to more than 10 years (slow recovery). Likewise, the "% Resources at Risk" were also divided into four categories with less than 10% representing a small percentage of the population and more than 50% as a large percentage of the population. The intermediary ranges for both axes were then further divided to provide some more definition to the matrix. The risk ranking matrix for this NEBA was based on summarizing 14 consensus ecological risk assessment (CERA) matrices generated through numerous CERA workshops throughout the United States, Mexico, the Caribbean and New Zealand.

The first step in the NEBA process was to evaluate the consequences of Natural Attenuation, which serves as a baseline. All subsequent rankings are relative to the baseline, i.e., are conditions better or worse for each resource when using each individual response options. Using the risk ranking matrix requires estimating the proportion of the resource affected, and how long it will take the resource to

recover. Based on the initial alphanumeric score, a level of concern ranking of High (red), Moderate (yellow) or Low (green) can be assigned.

		POPULATION RECOVERY			
		> 10 years (SLOW) (1)	>5 to 10 years (2)	>1 to 5 years (3)	< 1 year (RAPID) (4)
% of RESOURCE AT RISK	> 50% (LARGE) (A)	1A	2A	3A	4A
	>30 to 50% (B)	1B	2B	3B	4B
	>10 to 30% (C)	1C	2C	3C	4C
	0 to 10% (SMALL) (D)	1D	2D	3D	4D

Figure 17. Risk Ranking Matrix used in this analysis

A key factor in determining whether or not a resource is affected is to apply thresholds at which impacts, either acute or chronic, would be expected to occur for the various resource groups under consideration. In this case, two sets of thresholds, based on conservative (protective) assumptions were considered. The first set, used by Horn and French McCay (2014a and b), is shown in Table 9. In this approach, damage to shoreline ecological resources and habitats was assumed if oil contacted the habitat at a modelled concentration above 10.0 g/m^2. Impacts to birds, mammals and turtles on the water surface were assumed if there was a high probability of any contact with the modelled surface oil slick at slick thicknesses above 10 µm.

In the second approach shown in Table 10, the thresholds that can be most clearly quantified are those related to aquatic toxicity. This table which was first provided in Kraly *et al*. (2001) presents a series of concentration thresholds developed to address a range of organisms. These values are based on a qualitative review of published toxicity information initially developed for early CERA workshops. This table was included in the material reviewed by the Ocean Studies Board of the National Research Council (NRC) and included in their study (NRC, 2005). Additionally, a review of existing data from NRC and the DTox database (Bejarano, 2014) was conducted to compare the range of sensitivities reported for marine species tested for lethal and sub-lethal impacts from acute exposures to expected initial concentrations of dispersed oils following dispersant application in open waters, as well as in laboratory tests. Figure 15 was developed from this review. The more conservative threshold of 1 ppm is used in this analysis to conservatively protect sensitive species and juvenile life stages.

Table 9. Modelling Threshold Used to Define Regions with Potential Effects (Horn and French McCay 2014b)

Stochastic Threshold	Cut-Off Threshold	Rationale
Surface Oil Thickness	10 µm	Biological threshold for ecological impacts to the water surface (e.g., birds) (French *et al.*, 1996 & French-McCay 2009 oil spill fate and effects model). Oil would appear as a dark brown colour.
Shoreline Oil Mass	10.0 g/m^2	This thickness provides a more conservative screening threshold for potential ecological effects to shoreline habitats, which has typically been 100 g/m^2, based upon a synthesis of the literature showing that shoreline life has been affected by this degree of oiling (French *et al.*, 1996; French McCay 2009). The oil would appear as dark brown coat or opaque/black oil.
In Water Concentration	1.0 ppb of dissolved aromatics	Exposure concentration below which no noteworthybiological effects are expected for sensitive marine resources (Trudel, 1989 and French McCay, 2004) in S.L. Ross 2011 modelling for Old Harry in Gulf of St. Lawrence). This value is a conservative threshold for early contact on herring larvae.

Table 10. Water Column Thresholds in ppm of Total Petroleum Hydrocarbons (Kraly *et al.*, 2001)

Exposure	Level of Concern	Protective of Sensitive Life Stages	More Protective Criteria	Protective of Adult Fish	More Protective Criteria	Adult Crustacea/ Invertebrates	More Protective Criteria
0-3 hours	Low	<5	<1-5	<10	<10	<5	<5
	Medium	5-10	5-10	10-100	10-100	5-50	5-50
	High	>10	>10	>100	>100	>50	>50
0-24hours	Low	<1	<0.5	<2	<0.5	<2	<0.5
	Medium	1-5	.5-5	2-10	.5-10	2-5	.5-5
	High	>5	>5	>10	>10	>5	>5
0-96 hours	Low	<1	<0.5	<1	<0.5	<1	<0.5
	Medium			1-5	.0-5	1-5	.5-1
	High	>1	>0.5	>5	>5	>5	>1

The study team used all of the available information about the existing biological environment from the EIS and the oil trajectory analysis in the modelling reports, along with these toxicity thresholds, to develop ***levels of concern*** about the risk. The risk scores assigned in the risk matrix do not represent a prediction of actual impacts. Instead, they represent the level of risk assigned to a particular resource of concern from the different proposed response options.

3.3 Risk Analysis Results

As mentioned previously in Section 2.3, the best overall response to most large oil spills will almost always involve the integration of multiple response options. The reader is reminded that every response option has varying operational and logistics constraints that affect how quickly it can be deployed, and how much the particular response option can be "scaled up" based on many factors including access to remote areas, transit times for personnel and equipment. In addition, the decision-makers will need to set realistic expectations on how well each response option will work for the specific spill conditions. This NEBA is not suggesting that only one response option should be used, rather it is intended to consider the potential ecological consequences of each option (individually) to assist decision-makers in devising a response that minimizes overall ecosystem exposure to persistent oil, and promotes the most rapid overall ecosystem recovery.

The detailed results from the risk analysis are shown in Figure 18 and further detailed in the subsections that follow. As discussed in Section 2.4, the modelling results indicate that shoreline impact is an extremely low probability event. Therefore, the shoreline risk ranking results only apply to those circumstances where impacts to the shoreline (less than 2% of the modelled trajectories) are predicted.

			Reference Habitat*	Natural Attenuation	On-water Mechanical Recovery	On-water In-situ Burning	Surface Dispersants	Subsea Dispersants	Shoreline Protection & Recovery
Shoreline	Southern Tip of Nova Scotia	Mammals	R	3D	3D	3D	3D	4D	3D
		Birds	R	1A	1A	1A	1A	4D	1A
		Fish	R	4D	4D	4D	4D	4D	4D
		Invertebrates	R	4D	4D	4D	4D	4D	4D
		Plankton	R	4D	4D	4D	4D	4D	4D
		Vegetation	R	4D	4D	4D	4D	4D	4D
	Sable Island	Mammals	R	3A	3A	3A	3C	3D	2C
		Birds	R	1A	1A	1A	3B	3D	1A
		Fish	R	4D	4D	4D	4D	4D	4D
		Invertebrates	R	4D	4D	4D	4D	4D	4D
		Plankton	R	4D	4D	4D	4D	4D	4D
		Vegetation	R	4D	4D	4D	4D	4D	4D
	Recreational Fisheries		R	2A	2A	2A	2B	2C	2C
	Cultural and Subsistence		R	2A	2A	2A	2B	2C	2C
Shelf	Surface Layer	Mammals	R	2C	2C	2C	2C	3D	2C
		Birds	R	1A	1A	1A	1A	3D	1A
		Fish (larvae/eggs only)	R	4D	4D	4D	4D	4D	4D
		Sea Turtle	R	3D	3D	3D	3D	4D	3D
		Invertebrates	R	4D	4D	4D	4D	4D	4D
		Plankton	R	4D	4D	4D	4D	4D	4D
	Water Column (shallow; < 100m)	Mammals	R	4D	4D	4D	4D	4D	4D
		Sea Turtles	R	4D	4D	4D	4D	4D	4D
		Birds	R	4D	4D	4D	4D	4D	4D
		Fish	R	3D	3D	3D	3D	4D	3D
		Invertebrates	R	3D	3D	3D	3D	4D	3D
		Plankton	R	4D	4D	4D	4D	4D	4D
	Water Column (deep; > 100m)	Mammals	R	4D	4D	4D	4D	4D	4D
		Fish	R	4D	4D	4D	4D	4D	4D
		Invertebrates	R	4D	4D	4D	4D	4D	4D
		Plankton	R	4D	4D	4D	4D	4D	4D
	Benthos	Fish	R	4D	4D	4D	4D	4D	4D
		Corals & Sponges	L	4D	4D	4D	4D	4D	4D
		Other Invertebrates	R	4D	4D	4D	4D	4D	4D
	Commercial Fisheries		R	2A	2A	2A	2B	2C	2A
	Cultural and Subsistence		R	2A	2A	2A	2B	2C	2A
Slope	Surface Layer	Mammals	R	2C	2C	2C	2C	3D	2C
		Birds	R	1A	1A	1A	1A	3D	1A
		Fish (larvae/eggs only)	R	4D	4D	4D	4D	4D	4D
		Sea Turtle	R	3D	3D	3D	3D	4D	3D
		Invertebrates	R	4D	4D	4D	4D	4D	4D
		Plankton	R	4D	4D	4D	4D	4D	4D
	Water Column (shallow; < 100m)	Mammals	R	4D	4D	4D	4D	4D	4D
		Sea Turtles	R	4D	4D	4D	4D	4D	4D
		Birds	R	4D	4D	4D	4D	4D	4D
		Fish	R	3D	3D	3D	3D	4D	3D
		Invertebrates	R	3D	3D	3D	3D	4D	3D
		Plankton	R	4D	4D	4D	4D	4D	4D
	Water Column (deep; > 100m)	Mammals	R	4D	4D	4D	4D	4D	4D
		Fish	R	4D	4D	4D	4D	4D	4D
		Invertebrates	R	4D	4D	4D	4D	4C	4D
		Plankton	R	4D	4D	4D	4D	4C	4D
	Benthos	Fish	R	4D	4D	4D	4D	4D	4D
		Corals & Sponges	L	4D	4D	4D	4D	4D	4D
		Other Invertebrates	R	4D	4D	4D	4D	4D	4D
	Commercial Fisheries		R	2A	2A	2A	2B	2C	2A
	Cultural and Subsistence		R	2A	2A	2A	2B	2C	2A
Special Areas	Gully Marine Protected Area		L	2D	2D	2D	3D	4D	2D
	Roseway Basin		L	2C	2C	2C	3C	4D	2C

Figure 18. Results for the Risk Analysis (*R - Regional, L – Local)

3.3.1 Natural Attenuation

In approximately 95% of the modelling cases where oil does not reach the shoreline, the "level of concern" associated with natural attenuation is estimated to be low (recovery in less than one year), except for birds and marine mammals on the sea surface on both the shelf and slope, and recreational/commercial fisheries and cultural and subsistence use in all areas. The low level of concern for water column resources is based on low exposure levels given that the oil would remain largely on the water surface. However, even though it is evaluated as a low level of concern, naturally dispersed oil levels in the upper 10 to 20 m of the water column in the vicinity of surface slicks could pose a risk to plankton and fish eggs and larvae, if present in offshore locales and the spill occurs during spawning season. However, the anticipated area of effect in the water column for the total spill is not expected to be substantial (see Sections 2.4 and 3.1).

The level of concern for birds and fur-bearing mammals is judged to be much higher based on the following considerations drawn from the EIS, the oil spill modelling completed for this study, and past CERA findings:

- The largest concentrations of both birds and mammals occur over the continental shelf, while the oil trajectory stays mainly over the continental slope and the deep ocean. However the critical importance of these species, and the recognized patchy distribution of protected species, increased the level of concern for both percentage affected and time for population recovery.
- Federated Crude Oil weathers rapidly and during much of the year, especially in the winter, disperses rapidly into the upper water column.
- While the predicted area potentially affected by a surface slick is large, the actual footprint of the slick at any given time is relatively small (less than 10% of the reference area or RAA) and the oil older than several days would be highly weathered (emulsified and/or tar balls) and would pose less of a risk.
- Species vary throughout the year, but are present in all months.
- Individuals could contact oil and if so population recovery could take several years.

The level of concern for commercial fisheries in all regions is judged to be high based on the following:

- There will likely be an immediate closure of most, if not all, fisheries by Fisheries and Oceans Canada (with likely input or advice from Environment Canada and/or Canadian Food Inspection Agency) in the areas and/or for the resources considered affected by the spill.
- The affected fisheries are unlikely to reopen until monitoring of both oil distribution and tissue samples of species of concern reach acceptable levels, based on standards set by Canadian regulatory agencies.
- Fisheries closures in the Gulf of Mexico associated with the DWH incident were lifted within a year. Long-term population recovery studies are still ongoing.
- Typically, public trust tends to take a long time to recover.

The level of concern for cultural and subsistence uses in all regions (1A, concern for entire resource, recovey more than ten years) is judged to be high based on the following:

- This consideration has already been raised by First Nation stakeholders in association with the Project.

- Typically, trust levels by the public take a long time to recover.
- Experience from other incidents (i.e., Exxon Valdez) indicates that cultural and subsistence use concerns can remain a factor after more than 20 years, mostly due to chronic effects from shoreline impacts and persistance of oil in shoreline sediments. Oil at sea is expected to dissipate much more rapidly and produce less chronic effects.

Although shoreline oiling was determined to be a low probability event (i.e., less than 2% probability for both scenarios), the modelled trajectories suggested two areas at risk, the southern tip of Nova Scotia and Sable Island. The two highest concerns in these areas is for birds in the Important Bird Areas (IBAs) and marine mammals. The important bird species include the Leach's storm petrel and the Roseate tern (a critically endangered species). Surface oiling on Sable Island National Park Reserve has the potential to affect these populations. As a result, the level of concern score for these bird resources is 1A (more than 50% of the population at risk, more than ten years to recover). While surface oiling is expected to impact birds to a lesser extent on the tip of Nova Scotia given the lower concentration of these populations than on Sable Island National Park Reserve, the Level of Concern score is still a 1A because of the patchy distribution, meaning that oiling of even a small area could possibly hit the only patch of protected birds.

The important mammal species was identified as the grey seal on Sable Island where a sizeable portion of the North Atlantic population could be at risk. The level of concern score for this resource is 3A (more than 50% of the population at risk, recovery in one to five years). Other shoreline resources are at low risk (3D or 4D, recovery in less than one year) based on:

- Any oil reaching shore after 20 to 30 days (or more) will be extremely weathered (mostly tarballs) and represents less of a threat than fresh oil.
- High energy levels (especially in winter) in many areas will aid in rapid dilution, biodegredation and recovery.
- The available shoreline habitat potentially at risk is only a small portion.

3.3.2 Shoreline Protection and Recovery

Shoreline protection and recovery will not change any of the scores associated with habitats or resources of concern on the shelf or the slope relative to natural attenuation. Shoreline protection and recovery techniques may prevent some localized shoreline contamination, and will reduce the persistence of oil in treatable shoreline areas. However, the overall regional effect is not considered significant because the effectiveness of these options is heavily influenced by topographic and climatic conditions. The remote conditions along the Nova Scotia coastline, limited shoreline accessibility as well as the local weather conditions can pose formidable challenges to large-scale shoreline protection and recovery operations. The reader is refered to the OSRP for further information on Shoreline protection and recovery.

In low energy habitats care must be used to avoid exacerbating the damage caused by the oil. With appropriate response planning and implementation, a net improvement should be possible over natural attenuation, particularly in localized areas. Shoreline protection and recovery operations will be especially important and beneficial for marine mammals on Sable Island. For the island, the risk ranking was reduced from 3A (greater than 50% of the resource at risk, recovery in one to five years) to 2C (10-30% of the population at risk, recovery in five to ten years) because given 20 to 30 days to prepare

effective shoreline protection, which followed by aggressive shoreline removal and seal deterrance, could reduce exposure conside rably. This was not the case for birds, where it was judged that a large human presence could disturb the bird populations negatively, especially during nesting season, where eggs and chicks in non-oiled supratidal zones could be damaged by foot traffic. All shoreline activities in the area will have to be planned in conjunction with wildlfe specialists.

Other shoreline risk rankings were already low and are not expected to change, given that operations are expected to be localized and limited and some oil will still be present on shorelines that cannot be protected or completley cleaned. The levels of concern for cultural and subsistences uses, both on Sable Island and the southern tip of Nova Scotia are expected to improve with shoreline protection and recovery operations based on the visible activity and expected localized beneficial results. Shoreline protection and recovery efforts could also be targeted to areas of importance on southern tip of Nova Scotia where conditions permit. The levels of concern for these areas are reduced from 2A to 2 C, with shoreline protection reducing percentages affected, but still resulting in a recovery time of five to ten years.

3.3.3 On-water Mechanical Recovery

The levels of concern scores associated with on -water mechanical recovery are unchanged from the natural attenuation baseline, based on the logistic and weather limita tions discussed in Section 2.3 .3. The limited ability to utilize this option is expected to limit the overall regional ecological benefits over natural attenuation. Nevertheless, a worst case discharge may trigger the use of this response option which can remove a small amount of surface oil in localized areas where it is deployed (i.e. , localized benefits). While not enough to appreciably change the regional ecological consequences, it does provide some potential for surface oil removal in localized areas, and as a result does potentially provide a small net environmental benefit over natural attenuation.

3.3.4 On Water In-Situ Burning

The levels of concern scores associated with ISB are unchanged from the natural attenuation baseline, based on the logistic and weather limit ations discussed in Section 2. 3.4, as was the case for on -water mechanical recovery. The effectiveness of ISB is anticipted to be even less than on -water mechanical recovery because of prevailing sea state conditions in th e Project area , which limits the ecological benefits provided . However, this option could remove some small amount of the oil from the sea surface. While not enough to appreciably change the regional ecological consequences, it does provide potential for localized surface oil removal, and as a result does potentially provide a small net environmental benefit over natural attenuation.

Given the great distance from shoreline, air quality concerns over the rising plume were not considered a threat to human populated areas, and it is assumed that birds would avoid the smoke plume. Some small by-products from ISB can result in sinking burn residue. Components in the burn residue matrix is thought to have a low bioavailability and a review of bioassays from the Newfoundland Offshore Burn Experiment show little or no acute toxicity to aquatic organisms (Blenkinsopp *et al.,* 1997; Daykin *et al.,* 1994). Studies with several benthic organisms also indicated no acute toxicity and very low sublethal toxicity from burn residues generated in a laboratory (Gulec and Holdway, 1999). As a result of these past studies it was concluded that sinking burn res idue does not present an appreciable ecological concern.

3.3.5 Dispersant Application at Water Surface

Compared with an unmitigated spill, s urface dispersant application is expected to result in net environmental benefits for marine mammals and birds on the sea surface by reducing surface oil slicks . The trajectory modelling results indicate that the addition of surface dispersants is expected to reduce oil droplet size, increase the amount of oil that becomes entrained in the water column, and reduce the amount of oil at the surface. Any resurfacing oil would form slicks that are smaller in area, thinner, patchier and less persistent than they would be in an unmitigated case. Although surface dispersant use is expected to provide a net environmental benefit for marine mammals and birds, it it not expected to change the levels of concern for resources other than birds and mammals on Sable Island. Based on the natural resource information provided in the EIS and the limitations on surface dispersant application given the prevailing environmental conditions, the risk ranking for marine mammals and birds on both the shelf and the slope (in surface waters) are considered likely to remain unchanged between the unmitigated and surface dispersant scenarios . While aerial d ispersant application should be highly effective on encountered oil, the combination of weather conditions, day length (particularly in winter), and the difficult logistics given distance offshore, the ability to apply surface dispersants is expected to be limited. It is expected that the application of surface dispersants would result in only a 10 -20% reduction in surface oil in the first four days (i.e., the modelled duration) . As more dispersant operational resources became available, the percentage of surface oil that can be treated by aerial dispersants will increase, but the impacts of untreated surface oil will continue to cause potential impacts.

Surface dispersant application is also not considered to change the levels of concern for water col umn resources for reasons similar to those provided above. This includes the limited ability to deploy given environmental conditions and distance offshore, as well the limited total reduction in surface oil given these contraints. Although the use of surface dispersants is not expected to change the levels of concern to resources of concern on a regional scale, they may result in localized benefits in the areas where they are successfully deployed.

Using surface dispersant applications on surface oil will have localized benefits to organisms using the surface layers of the water column given its effects of reducing the surface slick and entraining oil in the water column. Although it will increase the amount of oil dispersed in the upper 10 to 20 m of the water column, oil will likely already be present in the water column through natural attenuation given prevailing environmental conditions in Nova Scotia. Thus, additional entrainment due to chemical dispersion will be incremental. C oncentrations of chemically dispersed oil will dilute rapidly as the oil moves through the water column over time . Within 2 -4 hours, concentrations typically decrease to below 10 ppm, which is approaching the threshold limit below which adverse ecological effects are not anticipated, even to sensitive species. The use of surface dispersants is therefore considered to provide a localized benefit to organisms such as birds and mammals using surface waters, and is not expected materially impact resources using the water column given the rapid dilution of dispersed oil and the low toxicity of the dispersants themselves (see Appendix A for a discussion of dispersant toxicity).

The levels of concern for cultural and subsistence uses and commercial fisheries remain high because of a lack of accurate informat ion on long -term recovery times, and the fact that public "perception" of damages may persist for decades . A common perception is that chemical dispersants are highly toxic and cause the entrained oil/dispersant mix to persist i n the environment. Although scientific studies

have demontrated this is not the case, the public perception still remains. The reader is referred to Appendix A for a general discussion on the fate and effects of dispersants.

Shoreline impacts are rare and have low levels of concern in the natural attenuation case, and these would not change with surface dispersant application. There are two exceptions to this. First, the level of concern for m arine mammals on the shoreline of Sable Island, where a major reduction in the percentage of the population of grey sea ls at risk is anticipated following the surface application of dispersants (new ranking 3C, down from 3A, recovery still in one to five year range). Second, the level of concern for birds at risk in the IBA is reduced from 1A to 3B, since less individuals would be affected, the population should recover in less time. Impacts to Sable Island are rare (see Section 2.4) but if they do occur they could be severe. As a result, surface dispersant application could lower, and even potentially eliminate, the risks to mammals and birds where it limits or prevents the surface slick from reaching the area.

3.3.6 Subsea Dispersant Injection

Subsea dispersant injection provides the greatest decrease in levels of concern assigned to resources at risk as compared to the levels of co ncern generated from natural attenuation. The lower levels of concern stem from the fact that subsea dispersant s can be effectively deployed with con tinuos operation, and their use does not cause a material increase in risk to the water column resources while greatly reducing the quantity of oil in shallower waters and on the water surface and shorelines. Dispersant use also reduced the likelihood that oil reaches shorelines and sensitive areas such as Sable Island National Park Reserve. Modelling indicates that this response option has the greatest potential to reduce surface oil, as well as reduce dispe rsed oil concentrations in the sensitive upper water column (surface to 100 m) where a variety of sensitive meroplanktonic resources are found.

Given that the application occurs at the spill's source, the exposures to dispersed oil in the deeper water column of the slope do increase, but the results from the trajectory modelling indicate areas exceeding the evaluation thresholds rarely occur (see Section 2.4). Dispersant injection occurs in an offshore area and at depths where sensitive resources are less common than in nearshore and shoreline environments. The area at the greatest risk is in the immediate vicinity (few kilometres) of the application point. Monitoring of subsea dispersant application during the DWH spill (Coelho *et al.,* 2012) indicated that concentrations of dispersed oil quickly diluted to below 1 ppm TPH within a few kilometres of the DWH well site, which is below nearly all conservative lethal thresholds and below most sub-lethal thresholds for sensitive marine species (NRC, 2005; see Figure 15). Additionally, while there were initially concerns during the DWH spill that the subsea dispersant injection could cause anoxic conditions at depth due to increased respiration from biodegradation, an extensive dissolved oxygen (DO) monitoring study was co nducted over a three month period during the response. M ore than 1,500 DO concentration measurements were recorded, and while a minor reduction of DO was reported in the dispersed oil plume (from biodegradation that was taking place), levels never dropped below the ecologically significant threshold of 2.0 mg/L. Refer to Figure 19 for a summary of the DO results. Th ese data suggest that subsea dispersant injection did not create any "oxygen depleted zones" in the Gulf of Mexico (Coelho *et al.,* 2012).

Underwater photographs collected as part of the Shelburne Basin Venture Seabed Survey conducted in 2014 around prospective wellsite locations, did not identify the presence of any aggregations of corals,

sponges or other benthic epifauna (Stantec, 2014c). No species of conservation interest were noted within the seabed study area, however the authors of this NEBA recognize that limited at -sea observations of the benthic environment is not a full characterization of species/resources in the deep waters of the slope.

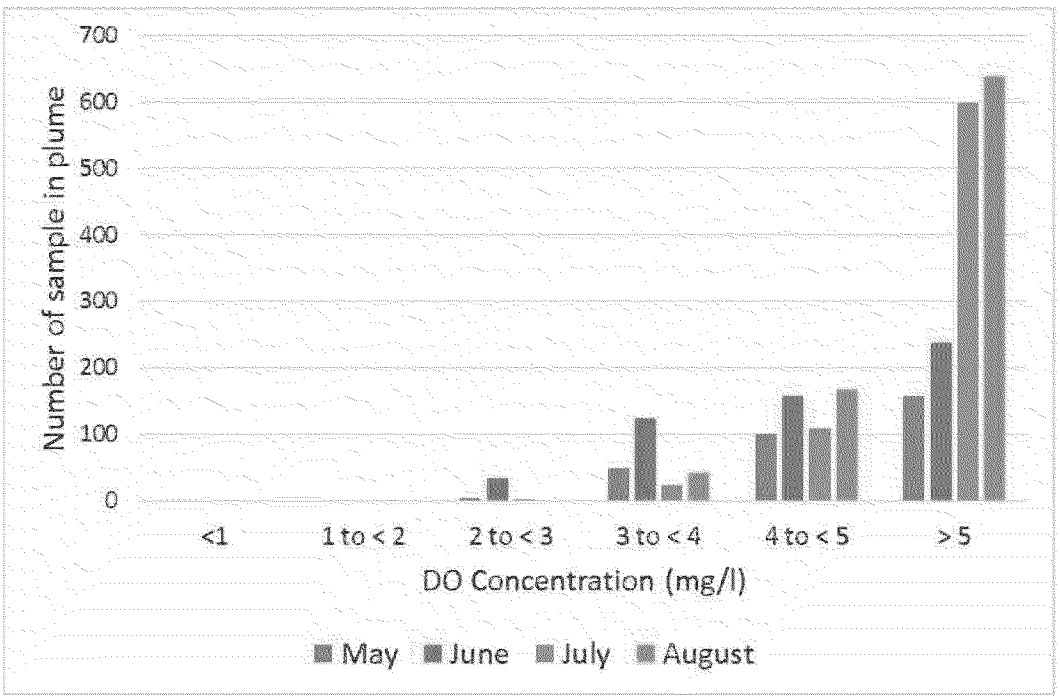

Figure 19. DO data from water samples collected during DWH spill (Coelho *et al.,* 2012)

Water column resources on the slope are not expected to be affec ted except in the upper water column, which would see less naturally dispersed oil. The changes to the levels of concern are as follows:

- Marine mammals and bird scores on the water surface in both the shelf and slope are reduced based on the decreased surface oil. This reduction is a conservative estimate because the smaller amount of surface oil could be such that natural weathering could eliminate it within days or less.
- The risk to sea turtles on the water surface in both the shelf and slope is reduced from 3D (less than 10% of the population at risk, recovery in one to five years) to 4D (less than 10% of the population at risk, recovery in less than one year) for the same reasons as described above.
- The risk to invertebrates in the shallow water column is reduced from 3D (less than 10% of the population at risk, recovery in one to five years) to 4D (less than 10% of the population at risk, recovery in less than one year) due to the reduction in naturally dispersed oil in the upper water column.

- The localized risk to invertebrates and plankton in the deep water column on the slope is increased based on the increase in exposure to dispersed oil in proximity to the discharge plume and application point. However, this is highly localized the the near vicinity of the well head.
- Finally, the perceived risk to fisheries and cultural and subsistence uses on the shelf should decrease from high to moderate as it becomes clear there is less oil, but public perce ption will still be slow to recover.

The remaining changes to the risk scores occur in shoreline habitats. Subsea dispersant injection has the potential to completely prevent this already rare event. With the application of subsea dispersant, no shoreline impacts would be expected to occur. Even if some surface oil remains , natural weathering processes would reduce the amount reaching shore, and this outcome is evaluated here. Important changes to the natural attenuation scenario occur for cultural and subs istence uses and for marine mammals and birds, as follows:

- The perceived risk to Cultural & Subsistence (both areas) is estimated to be reduced from due to the reduction in oiling. The benefit is greater here than on the shelf because the change will be more visible and obvious. However, even if the actual physical oiling approaches zero, public concerns will still remain, albeit lessened.
- The risk to marine mammals on the southern tip of Nova Scotia was reduced from 3D (less than 10% of the population at risk, recovery in one to five years) to 4D (less than 10% of the population at risk, recovery in less than one year) on the assumption that even less oiling will occur and impacts will essentially be restricted to a few individuals, without a measurable population impact.
- Similary, the level of concern for birds in the southern tip of Nova Scotia was reduced from 1A to 4D, and on Sable Island it was reduced from 1A to 3D for the same reason.
- The risk to marine mammals (grey seals) on Sable Island was reduced from 3A (greater than 50% of the resource at risk, one to five years to recover) to 3D (less than 10% of the population at risk, recovery in one to five years) because of the dramatically lowered exposure risk to a large population.

While a spill during breeding season for both the birds and mammals in shoreline habitats may critically affect the numbers impacted, especially in Sable Island, it is clear that dispersant application will always improve the condition over unmitigated surface oiling. As stated earlier, in the optimal case the rare impacts to shoreline resources could be completely eliminated by an effective subsea dispersant injection program. It is the only option which appears to realistically offer this outcome (see Section 2.3).

4 Summary

4.1 Critical Factors in the Analysis

This qualitative, NEBA analysis was conducted for oil spill contingency planning purposes, and is dependent upon a variety of input sources . It is intended to address the overall risk of a large scale subsea blowout event. Because it is intended to be a broad analysis of a large scale event, there is no specific season or trajectory analysis that will account fo r every possible spill scenario. However, it should represent likely exposure risks and levels of concern.

To conduct this study, the following important factors were considered and/or employed:

- the comprehensive environmental analysis conducted by Stantec;
- the comprehensive trajectory modelling using state-of-the-art models and including stochastic and deterministic scenario provided by ASA;
- reliance on the risk matrix which has been validated through numerous other studies;
- design of a scenario representing a high volume discharge incident for this area; and
- use of assumptions that were conservative and evaluated maximum extent of the impact.

4.2 Key Findings Related to Ecological Impacts

The most noteworthy result of the modelling analysis is the lack of shoreline impact in the vast majority of simulations for both treated and untreated slicks. Other summary results are as follows:

- Overall, the "level of concern" for long-term ecological harm from the modelled releases is low, in large part because of the great distance offshore and low predicted amount of oil that would encounter shorelines or nearshore environments (approx. 2%)
- Surface oil stays offshore (beyond the shelf/slope break) in most cases (over 95% of the time).
- Because of the characteristics of the oil and the environmental conditions in the North Atlantic , large amounts of hydrocarbon s enter the upper water column due to natural dispersion. However, water column concentrations of hydrocarbons are unlikely to exceed relevant thresholds, except in limited areas.
- Weathering of the surface oil is relatively rapid.
- Oil that reaches the shoreline (after 20 to 30 days) will be highly weathered (tar balls) and therefore adverse effects on resources will be less than with fresher oil.
- In the few instances where oil might reach the shoreline, the long travel time means that protective booming and shoreline recovery (done properly) could be planned and performed efficiently, but would not prevent all shoreline impacts.
- On-water mechanical recovery and in -situ burning are unlikely to substantially reduce adverse effects on ecological resources at a regional level. Some localized benefits may be provided from this activity.
- Natural dispersion and evaporation limit the area affected by surface oil.
- Aerial dispersant application to the sea surface will provide some benefit, especially early in the response, since it can be mobilized to the Source Control area faster than any other "at sea" response technique. Chemically dispersed oil droplets are preferred (over naturally dispersed

droplets) because they are smaller and form a stable oil -in-water emulsion that will not re-coalesce into a slick (because the dispersant lowers the interfacial tension of the droplet). As a result, chemically dispersed oil droplets will more readily and rapid biodegradation.

- Subsea injection of dispersants provides the greatest ecological benefit by retaining oil at depths and reducing the extent and concentration of surface oil and oil in the upper water column.
- Subsea dispersant injection increases hydrocarbon concentrations of oil in deep waters (close to the well site), but the affected areas are small relative to the overall Project area. The concentrations predicted do not represent a high level of concern to sensitive biological resources in those deep waters, and the concentrations should reduce fairly rapidly through biodegradation processes. It also lowers the level of naturally dispersed oil in the upper 10 to 20 m of the water column and at the surface.
- Aerial dispersant application may reduce surface impacts in treated slicks without a substantial increase in shallow water hydrocarbon concentrations, but the option can have logistical limitations given environmental conditions in Nova Scotia and will be less effective on highly weathered oil. As a result, aerial dispersants should be focused at relatively fresh oil at sea, since oil approaching shoreline areas will be too weathered for effective dispersant use.
- The risk to cultural and subsistence resources can be reduced by the use of subsea dispersants given that it reduces the likelihood that oil will reach the shoreline or sensitive areas such as Sable Island National Park Reserve. Further, SSDI is expected to promote more rapid biodegradation in deepwater, thereby removing oil from the ecosystem more quickly than other response options. However, the concerns from First Nations will likely remain high.
- The actual risk of various response options (specifically dispersants) to species that are important to commercial fisheries is low, but concern may remain high. Fisheries closures are likely to result from the spill itself, irrespective of whether dispersants or any other methods are used to assist in the response. The lengths of the closures may not change as a result of any of the response options, though subsurface dispersants may reduce the length of closures due to their potential effectiveness. Dispersant use may increase public concerns over seafood safety, though studies indicate their low toxicity.

4.3 Consideration of Other Scenarios

Since the purpose of this NEBA was to evaluate the ecological consequences of various response techniques, a summer season was selected with a Worst Case Credible Discharge volume. Since the summer weather conditions support all response options, this scenario allows for an even comparison of each option under a worst case release. During the winter season or during a storm event, it is reasonable to expect that higher sea states will exist and that some of these response options (e.g., on-water mechanical recovery, ISB and possibly protective shoreline booming) will no longer be operationally viable. As such, the feasible response options "at sea" during the winter (or a storm) may be limited to Natural Attenuation and Dispersant Use (surface or subsea). In higher sea state conditions, it is important to remember that while some response options may be suspended, natural dispersion from higher surface water mixing energy will play a larger role in the Natural Attenuation response option. In this case, monitoring activities can help provide valuable information on the degree of natural dispersion that is taking place, and can help inform decision-making as to the necessity for using chemical dispersants to further enhance the dispersion processes.

4.4 Recommendations Concerning Response Options

All of the response options evaluated offer the potential for a net improvement over natural attenuation, and none have material adverse consequences. All of them should be discussed and considered when developing an oil spill response plan. It is always assumed that a combination of response techniques will be used, as appropriate, to minimize oil exposure to sensitive resources and to promote rapid recovery of the ecosystem as a whole. The OSRP provides information on the integration and activation of multiple response options for this Project Area.

However, the response options vary greatly in their potential effectiveness in association with a large scale subsea blowout scenario, as summarized below (from least to most beneficial):

- **On-water In-situ Burning (ISB)** – This response option is severely restricted by seasonal day length, year-round weather conditions and logistical constraints. As a result, it is unlikely to offer substantial ecological benefits.
- **On-water mechanical recovery** – While this response option is constrained by factors similarly to those for ISB, on-water mechanical recovery resources are generally easier to obtain and deploy in larger numbers. Although this option is effective for smaller, confined spills, the estimated oil recovery for large-volume scenarios is generally associated with low ecological benefit.
- **Shoreline protection and recovery** – As a result of the low probability of shoreline contact indicated in trajectory spill modelling completed for the Project, this response option will have little overall effect, except in the rare cases where shoreline contact occurs. In these cases, this response option is essential. An effective response plan for protection of the ecological resources on Sable Island is the most important consideration.
- **Aerial dispersant application** – This response option was shown to be effective in substantially reducing surface oil in treated areas (the modelled oil is highly dispersible) but suffers from weather and logistic limitations. While it can be very effective in treating fresh oil, surface oil reduction is predicted to be 10-20% in the first 4 days of the spill. Hydrocarbon concentrations in the upper 10 to 20 m of the water column would increase in treated areas for a very short period, but would rapidly dilute and therefore not pose a long-term risk to the ecosystem (see text box in Section 2.3.5 on dilution rates). A water quality monitoring program would help define the spatial scale and longevity of dispersed oil plumes. This option could be very valuable

THE ROLE OF MONITORING

While the topic of response monitoring is outside the scope of this NEBA, it is noteworthy that implementation of appropriate operational (near real-time) monitoring* plans is needed to confirm efficacy of various response options and to modify response operations, as needed (e.g., adjusting DOR or skimming patterns).

In addition, environmental effects (longer term) monitoring studies are useful to assess the overall ecosystem recovery. Both operational and environmental monitoring are addressed in more detail in the OSRP.

** See Coelho et al. (2014) and API Technical Report 1152 (2013) for background information on operational monitoring.*

early in the release scenario while other response options, such as subsea disper sant injection equipment, is enroute.

- **Subsea dispersant injection** – This response option leads to the greatest net environmental benefit, and is recommended as a primary response option. The option provides the most improvement in risk scores for resources on the water surface and on the shoreline, without a major increase in risk to water column resources. While the predicted shoreline oiling was quite low in this scenario (approx. 2%), there is still considerable value in removing oil from the se a surface. Subsea dispersant injection has the potential to substantially reduce floating oil (potentially near zero, once implemented), as well as reduce dispersed oil concentrations in the sensitive upper water column (surface to 100 m). This dispersion at sea will enhance biodegradation in deeper waters farther offshore. Once in place, subsea dispersant injection is less sensitive to weather limitations than other available response options, and is the only one with the potential to operate 24 hours, seven days per week. Finally, this response option reduces the potential for exposure of surface vessels to volatile c omponents of the oil; reduces the need for surface recovery, in -situ burning, and surface dispersant operations, thereby reducing the potential for personnel exposure and accidents during these operations.

FOR MORE INFORMATION ON DISPERSANTS…

Dispersant research and development has been advancing for more than four decades, and there is a vast amount of information available on the topic. A more in depth discussion on dispersants, dispersant use, and the effects of dispersed oil can be found in these comp rehensive documents which provide excellent overviews on the topic.

- IPIECA Dispersants: Surface Application - Good practice guidelines for incident management and emergency response personnel (72 pages; published April 2015) available for free download at: *http://www.ipieca.org/publication/dispersants-surface-application*

- IPIECA Dispersants: Subsea Application - Good practice guidelines for incident management and emergency response personnel (published in June 2015) which will be available from: *http://www.ipieca.org/publication/*

- BP Oil Spill Dispersant Use Manual (129 pages; published in 2014) which is available as a free hard copy upon request.

- ExxonMobil Oil Spill Dispersant Guidelines (200 pages; published in 2008) available for free download at: *http://crrc.unh.edu/sites/crrc.unh.edu/files/exxonmobil_dispersant_guidelines_2008.pdf*

- Oil Spill Dispersants Efficacy and Effects, produced by the National Research Council (378 pages; published in 2005) available for free download at: *http://www.nap.edu/openbook.php?isbn=030909562X*

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APPENDIX A: An Overview of Dispersants

An overview on dispersants was included in the EIS (Stantec, 2014a), but has been included in this appendix for reference.

Operational Considerations

Oil spill r esponse strategies can include well control, remote sensing, mechanical on-water recovery, surface, aerial and subsea dispersants, in -situ burning, and shoreline protection and recovery. In many regions, the preferred method is to mechanically remove oil from the surface of the water when environmental conditions permit. Howe ver, past experience with offshore oil spills has demonstrated that mechanical equipment alone may not be sufficient for effective offshore oil recovery due to low encounter rates and reduced efficiency due to rough sea conditions. Operating in deeper wate rs and farther offshore brings challenges related to greater transit distances for boats supporting the response, and adverse weather conditions that can hamper safe operations and return to port. An effective response in a fast changing offshore environme nt requires access to all response options to be adaptable to a specific response scenario and to ensure maximum response effectiveness and environmental protection.

While mechanical recovery can be used on small operational spills, dispersants become a critical response tool for larger and spread out spills offshore. Surface application of dispersants offers the following advantages:

- Dispersants can be used over a wider range of environmental/ meteorological/ oceanographic conditions than other response options. They can be applied in rough seas (up to 3 m) and on thinner oil slicks (<<1 mm).
- Dispersant aircraft can typically travel to spill locations at speeds over 150 knots (170 mph; 275 kph) compared to 7 knots (8 mph; 13 kph) which is the typical sp eed of a response vessel transiting to a spill location. Arriving at the spill location quicker allows an effective response to start before slicks have spread, moved, or broken apart into smaller surface slicks.
- Large oiled areas can be rapidly treated by aircraft compared to alternative response methods.
- Aircraft are also able to travel between slicks located few kilometres apart in a matter of minutes, while vessel -based response options may require many hours to haul in the equipment, move to a new location, and redeploy the equipment.
- Dispersants remove oil from the water surface, therefore decreasing the risk for marine birds and mammals to come into contract with oil. The oil that disperses into the water column may pose temporary elevated exposure s to organisms in the immediate area, but research and experience has shown that those exposures are rapidly mitigated by the effects of dilution and microbial degradation of the dispersed oil. Dispersants use is usually recommended in the offshore areas deeper than 10 m.
- Dispersants protect shorelines. Surface oil may be driven by winds towards shorelines, while dispersed oil is typically carried away by currents.
- Dispersants delay/prevent formation of stable water -in-oil emulsions and, in some cases, bre ak emulsions already formed.

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Subsea dispersants application offers several additional advantages (API, 2013):

- Safety — subsea injection reduces the amount of oil coming to the surface and this in turn:
  (a) reduces the potential for exposure of surface vessels and personnel to volatile components of the oil and
  (b) reduces the need for surface recovery, in -situ burn, and surface dispersant operations, thereby reducing the potential for exposure of response personnel to accidents during these operations.
  Subsea application can reduce the potential for worker and public exposures by treating the oil where it is being discharged and preventing it from spreading or coming closer to shore.
- Oil Removal — Natural biodegradation processes will remove the oil from the environment as petroleum-degrading bacteria found world -wide consume the oil as a food source. Dispersant treated oil is rapidly diluted in the water column to the point that biodegradation can occur at very low concentrations without depleting oxygen or nutrient levels.
- Efficiency — Subsea injection may require markedly less dispersant compared to dispersing at the surface.
- Precision — Subsea application ensures that all dispersant is mixed with the oil at one manageable location before it spreads; instead of trying to treat widely spread oil slicks at the surface.
- Application — Surface dispersant applications require favorable weather conditions, while subsea dispersant injection from a vessel can proceed in a much broader range of conditions.
- Timing — Application can occur around the clock, whereas surface (aerial and v essel) applications are usually restricted to daylight hours.
- Effectiveness — The operational effectiveness of dispersant applications subsea is likely to be more effective as the oil being treated has not undergone extensive weathering. Turbulence naturally associated with the blowout jet could create droplets more effectively than breaking waves at the surface.
- Encounter Rates - Subsea injection has higher oil encounter rates than any other response technique.

For these reasons, in addition to mechanical recovery, the appropriate use of dispersants, applied either at the ocean's surface or subsea, may provide the means of removing sizeable quantities of oil from the surface quickly, therefore reducing overall environmental impacts from the spill to the sensitive near shore and shoreline environments. It is important to note that dispersants are most effective on fresh and unemulsified oil, so time in securing the approvals for dispersants use is critical to ensure that oil is still amendable to dispersio n. This is less relevant for a blowout scenario as fresh oil comes to the surface every day, but approval timing becomes critical for batch spill responses as dispersants use may have a very narrow "window of opportunity". To facilitate decision making, in dustry and government agencies are working together prior to the spill to use Net Environmental Benefit Analysis (NEBA) principles to consider the consequences of using dispersants to move the oil into the water column where it can rapidly dilute and biode grade, against the impacts of oil left on the water surface or oil stranding on shoreline if mechanical containment and recovery efforts are ineffective or inefficient.

Dispersants have traditionally been applied at the water surface by properly equipped vessels, helicopters, and fixed-wing aircraft. There are many examples of dispersant use in North America in the past fifteen years that involved smaller volumes of dispersant application, including these events:

- T/V Mega Borg – 1990 (dispersant test only)
- West Cameron Block 168 Oil Spill – 1995
- High Island Pipeline System Spill – 1998
- T/V Red Seagull – 1998
- BP-Chevron Pipeline – 1999
- Blue Master – 1999
- Poseidon Pipeline – 2000
- Main Pass 69 Oil Spill – 2004
- Shell Pipeline Ship Shoal Block 142 – 2009
- Galveston Endeavor vs. M/T Krymsk – 2009

Another notable example of dispersant use is the Sea Empress oil spill (1996) where large volumes of dispersants were used near -shore to help protect sensitive resources from the impacts of floating oil. The use of around 445 tonnes of chemical dispersants sprayed by aircraft onto the oil slicks at sea prevented at least 36,000 tonnes of oil, from the Sea Empress coming ashore in this sensitive region of Wales.

Prior to this, the largest use of dispersant was during the 1979 IXTOC -1 spill in the Bay of Campeche, Mexico where 1 to 2.5 million gallons (~4 to 10 million litr es) of dispersants were applied over a five - month period (EPA online, 2011)

The DWH incident was the first response where large quantities of dispersants (approximately 53,000 tonnes) were applied using a combination of aerial, vessel, and subsea dispersant application methods. As a result of the innovative use of subsea dispersant injection during the DWH incident, new techniques for subsea dispersant use are now available and the knowledge on this topic is evolving rapidly.

Principles of Chemical Dispersion

Some portion of released oil will likely disperse into water column whether chemical dispersan ts were used or not. Natural dispersion of floating oil is a process facilitated by wave action that breaks the oil into small droplets and disperses them into the water column. It is affected by the properties of the oil, and the amount of wave energy at the sea surface. In general, oils with lower viscosity are more amenable to natural dispersion than those with higher viscosity, and higher wave energy produces more natural dispersion. Very small oil droplets (less than 100 micrometers in diameter) generally tend to stay suspended in the water column and eventually biodegrade, while larger ones are more likely to float to the surface and can re-coalesce into a slick.

Natural dispersion also occurs during subsea discharges and is largely dependent on d roplet size which, in turn, is dependent on discharge velocity, release rate, and oil to gas ratio. Like surface spills, droplet sizes less than 100 micrometers in diameter typically remain dispersed in the water column and degrade

whereas larger droplets are more buoyant and will generally float to the surface and form floating oil slicks.

Chemical dispersants are surfactants . While there are a few dispersants formulated for use in fresh or brackish water, these are uncommon and not relevant to this Proj ect Area, so this discussion will focus on the majority of dispersants which are formulated f or use in marine environment s. They enhance natural oil dispersion by reducing the surface tension at the oil/water interface, making it easier for waves or turbulence to create small oil droplets. Modern chemical dispersants are a blend of surfactants (surface active agents) in a solvent. The solvent has two functions: it reduces the viscosity of the surfactant which enables it to be sprayed and it promotes the pen etration of the surfactant into the oil slick. The surfactant molecules are the key component of the dispersant. They are made up of two parts: an oleophilic part (oil-loving) and a hydrophilic part (water-loving). When dispersants are sprayed onto an oil slick, the solvent transports and distributes the surfactants into the oil slick and the surfactants reduce the surface tension at the oil/water interface. As a result, small oil droplets are formed, which break away from the oil slick with the help of w ave energy. Re-coalescence is minimized by the presence of the surfactant molecules on the droplet surface.

As an example of dispersant composition Table A1 lists ingredients of Corexit® EC9500A as well as alternative daily uses of its components.

Table A1. Corexit® EC9500A Ingredients.

CAS #	Name	Common Day-to-Day Use Examples
1338-43-8	Sorbitan, mono-(9Z)-9-octadecenoate	Skin cream, body shampoo, emulsifier in juice
9005-65-6	Sorbitan, mono-(9Z)-9-octadecenoate, poly(oxy-1,2-ethanediyl) derivs.	Baby bath, mouth wash, face lotion, emulsifier in food
9005-70-3	Sorbitan, tri-(9Z)-9-octadecenoate, poly(oxy-1,2-ethanediyl) derivs	Body/Face lotion, tanning lotions
577-11-7	* Butanedioic acid, 2-sulfo-, 1,4-bis(2-ethylhexyl) ester, sodium salt (1:1)	Wetting agent in cosmetic products, gelatin, beverages
29911-28-2	Propanol, 1-(2-butoxy-1-methylethoxy)	Household cleaning products
64742-47-8	Distillates (petroleum), hydrotreated light	Air freshener, cleaner

* Contains 2-Propanediol

Factors that Affect Dispersant Effectiveness

Surface Application

Dispersant effectiveness for surface applications is influenced by the efficiency of the application process (encounter rate), the dispersibility of the oil, and the sea state (wave energy). Factors that affect oil dispersibility include the viscosity, pour point, chemical composition, and the degree of weathering.

Many crude and some refined products tend to form stable emulsions over time when mixed with water by wave action, which can be difficult to b reak and disperse. For surface oil, the time window within which dispersants are effective is generally less than a few days after which the oil usually becomes too viscous or emulsified. Another important limitation for surface dispersant application is v isibility. Aerial dispersant application can only be performed under conditions where visibility is sufficient to allow accurate slick targeting. Therefore aerial dispersant application can be restricted by poor weather (i.e., low cloud ceiling) and can only be conducted during daylight hours.

The encounter rate for surface dispersant application is affected by the speed of the delivery system (i.e., workboat vs. multi engine aircraft), the amount of dispersant that can be carried, the width of the spray pattern, and the ability to deliver dispersants in small droplets capable of entering the oil without "punching through" to the water below. The optimum dispersant droplet size is generally considered to be about 600 to 800 µm. The targeted initial dispersant-to-oil ratio (DOR) for surface application of modern dispersants is generally around 1:20 . This ratio may need to be adjusted down to a lower DOR for heavy crudes or more heavily weathered oil. Likewise, a higher DOR may be appropriate for particularly light crude oils. Operational efficacy monitoring during aerial dispersant application will help inform decision-makers on the optimum DOR needed for a specific set of spill conditions.

Sea state is important for surface dispersant application because it affects both the distribution of the oil and the mixing energy available for breaking slicks into small droplets. If the wave energy is too low, the oil may not be effectively dispersed into the water column and droplets may coalesce, float to the surface, and form an oil slick . If wave energy is too high, the oil can be submerged by breaking waves, preventing direct contact between the dispersant and oil. Poor weather conditions can also affect the safety of surface spraying operations. Optimum wind speeds for surface dispersant application is about 5 to 25 knots.

It is important to note some key distinctions between chemical dispersion and natural dispersion. First, natural dispersion will begin to occur at breaking wave heights (i.e., when white c aps form), which can translate to varying wave heights depending on many factors including the speed and direction of both ocean currents and wind. As a result, in lower wave heights of approximately 2 metres or less, natural dispersion will not be as domi nate a factor as in higher sea states. Naturally dispersed oil droplets are not as small as chemically dispersed oil droplets and are not as stable in the water column. In other words, naturally dispersed droplets have a much greater likelihood of re -coalescing into a surface slick when wave action calms, reducing chances of biodegradation. When dispersants are applied, the interfacial tension of the oil droplets is permanently reduced, resulting in smaller chemically dispersed oil droplets that are more st able as an oil -in-water emulsion, and therefore will not likely re -coalesce. These smaller, stable chemically dispersed oil droplets will promote faster biodegradation.

The viscosity and pour point of a given oil provide a good indication of its dispersi bility. Fresh light to medium crude oils are considered to be readily dispersible whereas highly viscous oils are not. The

upper limit of dispersi bility is likely to be reached with heavier oils (group 4 oils [2]). As a general rule, dispersant effectiveness will decrease as oil viscosities increase. They are likely to be ineffective for oils with an initial viscosity above 10,000 cSt. Pour point is also an important parameter. Any oil with a pour point higher than the ambient temperature may become very visco us or semi -solid and loose its dispersibility.

Subsea Application

Subsea dispersant application was first used in the DWH response in 2010 and information on the associated scientific monitoring can be found in Coelho *et al.,* 2012. Currently industry, aca demia and other research organizations are making concerted efforts to learn more about the effectiveness of this response option and the potential fate and effects to the deepwater environment. Research is underway to determine how the various factors suc h as temperature, pressure, gas -to-oil ratio, etc., affect subsea dispersant application methodology and effectiveness. Additionally, testing of low -solvent dispersants is underway to assess their utility for subsea injection.

Several of the limitations that apply to surface application may not affect subsea dispersant injection. For example, subsea injection is relatively unaffected by weather and sea state. As the encounter rate is much higher due to more accurate targeting of the released oil by the dispersant application system, the DOR needed to promote effective dispersion is much lower. Optimum DORs for subsea use are still the subject of ongoing research, but based on the DWH incident and recent research, an initial application rate of 1:100 is thought to be an appropriate target, as opposed to 1:20 for surface use. The rate can be adjusted during a response event to optimize the effectiveness, based on real -time subsea dispersant monitoring data. Efficiency of subsea dispersant injection is likely to be higher than surface dispersion as dispersants are applied directly into fresh, warm oil with low viscosity in a zone of high turbulence facilitating formation of small droplets.

Laboratory Testing of Dispersants Efficiency

In September, 1994, the US Environmental Protection Agency (EPA) officially adopted the swirling flask test (SFT) as its official laboratory screening methodology for testing the effectiveness of dispersants in seawater. The SFT is based on the protocol first developed and adopted by Environment Canada in the 1980s. It essentially consists of a procedure in which a pre -mixed solution of crude oil and dispersant is added to a specially designed glass side -arm flask containing 100 ml artificial seawater and the contents of the flask mixed on an orbital shaker for 10 min followed by a settling time of 10 min. The dispersed oil mixture is then extracted and measured in a spectrophotometer to determine the quantity of oil that had been dispersed into the water column. Listing of a dispersant on the US national contingency plan (NCP) product schedule has been contingent on the dispersant being at least 45% effective (50 ± 5%) in dispersing Prudhoe Bay and South Louisiana crude oils in the laboratory test. The pro cedure is simple, inexpensive, and straightforward. After the SFT was adopted in the final EPA regulation promulgated in September 1994 and described in Appendix C, Subpart J of 40 CFR 300.900, it was re-examined after its first year of use. Re-examination was pursued because of the discovery that unexpectedly large

[2] For more information, please see the 2011 International Tanker Owners Pollution Federation, Ltd., Technical Information Paper (TIP) titled *Fate of Marine Oil Spills*, available online at http://www.itopf.com/information-services/publications/documents/tip2fateofmarineoilspills.pdf.

discrepancies had been observed between the data submitted by dispersant manufacturers and those generated by EPA contract laboratories for numerous products on the NCP product schedule. Thus, in 1999, EPA decided to rigorously investigate the SFT to under stand and resolve its apparent ambiguities and possibly come up with a better, more reproducible protocol. The results of the research have been submitted, and a new methodology was developed ba sed on a new flask design. The flask is a 150 ml baffled trypsinizing flask used in biological science research and clinical laboratory testing. The new protocol was named the baffled flask test (BFT) (Venosa *et al.*, 2002).

Neither of these tests has been designed to simulate dispersion under actual offshore conditions, however, they do provide a sufficient rationale to screen candidate dispersants without quantitatively predicting efficiency under real world conditions. For the assessment of oil disp ersant effectiveness under real sea state conditions, test protocols are required to have hydrodynamic conditions closer to the natural environment, including transport and dilution effects. To achieve this goal, Fisheries and Oceans Canada and the US Envi ronmental Protection Agency (EPA) designed and constructed a wave tank system to study chemical dispersant effectiveness under controlled mixing energy conditions (regular non -breaking, spilling breaking, and plunging breaking waves). Several dispersion te sts conducted in this tank demonstrated high effectiveness of dispersants far exceeding those observed in bench-scale tests.

The U.S. Minerals Management Service (MMS) funded and conducted two series of large -scale dispersant experiments in cold water at Ohmsett – The National Oil Spill Response Test Facility, in February–March 2006 and January –March 2007. Alaska North Slope, Endicott, Northstar and Pt. McIntyre crude oils and Corexit 9500 and Corexit 9527 dispersants were used in the two test series. The crude oils were tested both when fresh and after weathering. Results demonstrated that both Corexit 9500 and Corexit 9527 dispersants were 85 –99% effective in dispersing the fresh and weathered crude oils tested at cold temperatures. (Belore *et al.*, 2009)

While existing tests can be used to select dispersants for subsea application, several projects are under way to develop new equipment and protocols to more closely simulate specifics of subsea dispersants injection and evaluate dispersants under broader range of conditions.

Toxicity of Dispersants and Dispersed Oil

In general, the toxicity of modern dispersants (those maintained within the Global Response Network) is much less than the toxicity of the crude oil itself. Aquatic toxicity for short -term e xposures is usually described using LC50 (Lethal Concentration) endpoints. The LC50 is the concentration that causes acute mortality in 50% of test organisms in a specified time period (usually 48 or 96 hours). The greater the LC50 value, the lower the tox icity; that is, a higher concentration is required to produce a specified adverse effect.

Environment Canada has done extensive testing of dispersants and chemical cleaners (Fingas, *et al*., 1991, 1995) using standard tests with rainbow trout to assess the toxicity of more than 60 products. Common household detergents were included for comparative purposes and to help provide the proper perspective on dispersant toxicity. Table A2 shows that today's dispersants are an order of magnitude less toxic to rainbow trout than common household detergents are.

Table A2. Environment Canada Aquatic Toxicity Comparison of Household Cleaners and Dispersants (dispersants are shown in red)

PRODUCT	RAINBOW TROUT 96 HOUR LC50 (PPM)
Palmolive	13
Sunlight	13
Bioorganic (surface washing agent)	18
Mr. Clean	30
Citrikleen XPC (surface washing agent)	34
Enersperse 700	50
Corexit 9527	108
Corexit 9500	354

Furthermore, the US EPA evaluated the eight commercially available dispersants and found that the dispersants tested had different levels of toxicity, but Corexit® EC9500A, was among the least toxic. Ultimately, the crude oil by itself was found to be more toxic to the test species than the dispersants alone; the dispersants alone were less toxic than the dispersa nt-oil mixture; and the oil alone displayed toxicity results similar to the dispersant-oil mixtures (EPA ORD, 2010).

The US EPA has established a scale (Table A3) for interpreting laboratory -generated aquatic toxicity information using LC50 values (mg/L = ppm). The aquatic toxicity results for two key test species (mysid shrimp and silverside, a small fish also known as Menidia) as determined by EPA for Macondo crude oil, the dispersant Corexit® EC9500A, and the oil-dispersant mix are shown in Table 3.

Table A3. EPA Aquatic Toxicity Testing Summary for Oil, Dispersant, and Dispersed O il (EPA ORD, 2010)

	Louisiana Sweet Crude (LSC) Oil		Dispersant (Corexit 9500)		Dispersed Oil (LSC + Corexit 9500)	
Species Tested	Mysid Shrimp	Menidia beryllina (Fish)	Mysid Shrimp	Menidia beryllina (Fish)	Mysid Shrimp	Menidia beryllina (Fish)
Very Highly Toxic						
Highly Toxic						
Moderately Toxic	2.7 ppm	3.5 ppm			5.4 ppm	7.8 ppm
Slightly Toxic						
Practically Non-toxic				130.0 ppm		

The toxicity of dispersed oil varies considerably among different types of organisms, and also among life stages for some organisms. In general, for most aquatic organisms, the 96hr LC50 for dispersed oil is on the order of 20 -50 ppm. Larval and embryonic life stages for some organisms can be much more

sensitive, and may be adversely affected by concentrations as low as a 1 -5 ppm. While some sub-lethal impacts could take place even at low hydrocarbon concentrations, due to fast dilution of dispersed oil in the ocean noteworthy adult mortality effects on adult fish populations from dispersant use in the last 40 years have not been observed.

Although standard toxicity tests can be used to produce a numerical measure of a substance's aquatic toxicity and provide important information about the effects of oil and dispersants, many of these tests do not accurately reproduce the different types of exposures organisms may experience during an actual oil spill.

The magnitude of toxic effects is determined by the exposure that organisms receive, which is governed by:

- The concentration of dispersed oil to which they are exposed; and
- The duration of time for which the exposure persists.

Available data suggest that, following initial dispersion, maximum dispersed oil concentrations are less than 50 mg/L and that dispersed oil concentrations reduce to 1 to 2 mg/L in less than 2 hours (Cormack and Nichols, 1977; McAuliffe *et al*., 1980 and 1981; Lunel, 1994; Strom-Kristiansen *et al*., 1997; Daling and Indrebo, 1996). Trudel *et al*. (2009) showed that, even in closed wave tanks, concentrations of dispersed oil are rarely higher than 100 mg/L. With time, dispersed oil plumes continue to dilute and offshore concentrations of dispersed oil are estimated to fall below a threshold for acute impacts in less than a day (Cormack and Nichols, 1977; McAuliffe *et al*., 1980; IPIECA, 2001; French McCay and Payne, 2001; French McCay *et al*., 2006). As a result, exposure of water column organisms to offshore dispersed oil (chemically or physically) is short and limited to the top few metres of the water column during application of dispersants at the water surface (vessel/aerial) (Potter *et al*., 2012). Small-scale field tests have indicated that dispersants also rapidly dilute even in the absence of dispersed oil. Concentrations of dispersant in water have been shown to reduce to less than 1 mg/L within hours, which are generally below estimated toxicity levels derived from experiments with constant exposure (NRC, 1989). These concentrations are very different from typical laboratory test protocols which typically use a constant concentration over a fixed amount of time (typically 48 to 96 hours), making it difficult to extrapolate results of laboratory experiments into realistic impacts in the field. Bejarano *et al.* (2014) discussed the large variety in exposure methods, oil type and treatments and the complications when interpreting and applying these data for impact assessments. During the DWH incident, subsea dispersant injection occurred more or less continuously, and concentrations of dispersant and dispersed oil were monitored throughout the duration of the response. Due to potential conflicts with response operations and safety concerns, most of the subsea monitoring was conducted outside of an exclusion zone of 1 km from the well head. Beyond the 1 km exclusion zone, a subsea dispersed oil plume usually existed but was typically narrow, trended away from the site in the direction of very slight subsea currents, and was bounded by depths of about 1100-1300 m. According to Lee (2013), from 2779 individual samples collected in that area only 33 samples had TPH concentration higher than 10ppb.

While some short term toxicity to certain species can occur in the immediate vicinity of oil dispersant application operations, it is important that the resultant toxicity be considered within the context of the overall impacts of dispersed and undispersed oil on all potentially affected ecosystems (NEBA approach).

Comparative sensitivity of cold water and temperate species

There has been a considerable effort in the past five to ten years to better understand the sensitivity of cold water species to dispersed oil. The majority of studies have been conducted with crude oil or individual polycyclic aromatic compounds exposing mainly copepods and fish larvae. (e.g., Christiansen *et al*., 1996; Ingebritsen *et al*., 2000; Perkins *et al.*, 2005; Jensen *et al*., 2008; Baussant *et al*., 2009; Skadsheim *et al*., 2009; Jensen and Carroll, 2010; Hansen *et al*., 2011; Hjorth and Nielsen, 2011; Grenvald *et al*., 2013). Several studies addressed the toxicity of chemically and physically dispersed oil (e.g., Hansen *et al*., 2012; Gardiner *et al*., 2013; McFarlin *et al*., 2011). These studies showed that while dispersants temporarily increase the concentration of oil in the water column, for field-relevant concentrations, the same concentration of chemically dispersed oil is no more toxic than physically dispersed oil and that the dispersants' acute toxicity only occurs at much higher water column concentrations than expected with any proposed use of the dispersant product.

Although regionally specific toxicity data are sometimes desired, there are several practical challenges with testing arctic species in standard laboratory tests. A number of studies have, therefore, assessed the potential relevance of temperate species toxicity data for assessing cold water species' sensitivity (De Hoop *et al*., 2011; Olsen *et al*., 2011; Word and Gardiner, in prep). There is a body of evidence that indicates that, based on acute effects, cold water species are no more sensitive than temperate species to petroleum related compounds. Several studies indicated that cold water species require a longer period of time to exhibit effects associated with petroleum exposures (Chapman and Riddle, 2005; Olsen *et al*., 2011, Gardiner *et al*., 2013; Hansen *et al*., 2013). Many factors can explain the increased response time of cold water species as they have a number of morphological and physiological adaptations to survive at cold temperatures (e.g., lipid stores, decreased metabolic rates for some larger body size compared to temperate counterparts, and slower digestion) that may affect toxic responses (De Hoop *et al*., 2011). Olsen *et al*. (2011) and De Hoop *et al*. (2011) concluded that toxicity data for temperate regions are transferrable to the cold regions for the chemical 2-methyl naphthalene, naphthalene, and physically and chemically dispersed oil, as long as extrapolation techniques are properly applied and uncertainties are taken into consideration. These findings are supported by Word and Gardiner (in preparation) who compare the relative sensitivity of arctic and non-arctic species using measured and literature data. A report from the Norwegian Research Council that reviews 10 years of research on long-term environmental effects of the oil and gas industry (NFR, 2012) concludes that cold water organisms themselves are not necessarily more sensitive to oil discharges than temperate organisms.

Dispersed Oil Biodegradation

Chemical dispersants are specifically designed to enhance natural dispersion by reducing the surface tension at the oil/water interface and making it easier for waves to create small oil droplets with larger surface area. This provides naturally occurring oil degrading bacteria greater access to the oil by creating a dilute mixture of oil droplets with high surface area rather than a thick surface accumulation with less surface area relative to volume. Fortunately, oil degrading bacteria are present in all marine environments (Prince *et al*., 2010a, 2010b; Atlas and Hazen, 2011). To date, there are over 500 microbial species of bacteria, fungi and algae that have been recognized to be capable of degrading petroleum

hydrocarbons (Head *et al*., 2006; Yakimov *et al*., 2005). Biodegradation by indigenous microbial communities is the major process for weathering and eventual removal of oil from marine environments (Atlas, 1995; Atlas and Bartha, 1992; Atlas and Hazen, 2011; Leahy and Colwell, 1990). Studies have shown that oil degrading microbes colonize dispersed oil droplets within a few days. This is a natural process by which hydrocarbons are transformed into less harmful compounds through the metabolic or enzymatic activity of microorganisms that are able to gain energy as well as carbon from this process. Petroleum hydrocarbons may be degraded to carbon dioxide, water and cellular biomass or degraded to smaller products that can undergo successive degradations until the compound is fully mineralized (Kissin, 1987; Mango, 1997).

Bacteria in cold environments have metabolic rates comparable to those observed in more temperate climates and the rates of microbial growth in different environments are relatively similar despite temperature difference. Zahed *et al*. (2011) found a 'half-life' of approximately 30 days for a light oil in seawater from Malaysia at 28°C. Similar experiments with New Jersey seawater at 8°C suggested a 'half-life' of 14 days (Prince *et al*., 2013) while others with Arctic seawater at -1°C yielded a 'half-life of approximately 60 days (McFarlin *et al*., 2014). Bagi *et al*. (2014) followed naphthalene biodegradation in pristine water samples collected from the North Sea and the Arctic Ocean, and found three-fold faster naphthalene degradation rate coefficients in the latter at temperatures from 0.5 to 15°C.

The EPA recently conducted a study on dispersed oil biodegradation using concentrations approaching expected field concentrations (Venosa and Holder, 2007). They studied the biodegradation of dispersed Alaska North Slope crude oil at two temperatures and two concentration ranges: nominally 50 mg/L and 5 mg/L. They found rapid biodegradation at 20°C (greater than 80% of the alkanes consumed in 30 days) and only slightly reduced biodegradation rates at 5°C (greater than 80% of the alkanes consumed in 40 days).

Studies conducted during Deepwater Horizon oil spill in deep cold waters of the Gulf of Mexico showed that microbial respiration within the oil slick was higher by approximately a factor of five compared to respiration rates observed outside the oil slick (Edwards *et al*., 2011). The average half-life of alkanes was found to be the range of 1.2-6.1 days while decreases in aromatic hydrocarbons were observed to be on the scale of weeks to months (Hazen *et al*., 2010; Boehm *et al*., 2011).

These and many other studies prove that crude oil can be effectively biodegraded by bacteria naturally present in the sea water even in cold water environments like those in Nova Scotia. Dispersing oil in the water column facilitates natural biodegradation by increasing the surface area available for bacterial colonization and ensuring fast dilution of the plume to the levels that bacteria always have access to sufficient amount of nutrients and dissolved oxygen. Biodegradation of oil, and especially emulsified oil, at water surface and biodegradation of oil stranded on the shoreline is expected to have much slower biodegradation rates due to limited surface area available for bacterial colonization, high oil concentration, and as a result potential deficiency in nutrients.

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APPENDIX B: Biographies for NEBA Authors

Dr. Gina Coelho is a Principal Professional Associate and Subject Matter Expert for HDR. She has over 25 years' experience in environmental research, consulting, program management, group facilitation and regulatory compliance. Since joining EM&A as one of the founding memb ers in 1996, she has worked extensively in the field of dispersant and dispersed oil research. After starting EM&A, Dr. Coelho completed her Ph.D. dissertation which focused on dispersant use and response policy for 22 countries and territories around the world. She has conducted open ocean oil field trials (Norway and UK), mesocosm research (Coastal Oil Spill Simulation System, TX and SINTEF Tank Testing, Norway) and laboratory experiments (at the EM&A toxicity testing laboratory, MD) on the efficacy and b iological effects of oil, dispersant, and dispersed oil. She has worked as a co -facilitator (with Dr. Aurand) on more than a dozen Ecological Risk Assessments for the US Coast Guard, has set up three dispersed oil testing facilities (in the US, Brazil, and New Zealand), and has taught several courses, including "Understanding Oil Spill Response" and "Dispersant Use and Planning." Dr. Coelho served as a HazMat Response Incident Commander to McMurdo Station, Antarctica, for the National Science Foundation dur ing the 1999-2000 austral summer. She has served as Environmental Unit leader and Chief Scientist on other oil spill responses. From 2005 to 2008 she served as co -Principal investigator on a NOAA Coastal Response Research Center (CRRC) funded project to ex amine life-cycle and multi -generational effects of oil and dispersed oil on a marine organism, and again in 2012 -2013 on a second NOAA CRRC project to develop a dispersed oil toxicity database to support oil spill response decision-making.

During the BP DWH spill, Dr. Coelho served as BP's chief scientist to design and conduct the two subsea dispersant injection tests to assess the feasibility and efficacy of a long -term subsea operational dispersant response. She developed the associated subsea monitorin g operation in support of this dispersant injection strategy, and under USEPA Directive, retested all of the USEPA NCP dispersants to develop efficacy and toxicity data specific to MC252 oil. She has continued to serve in an oversight capacity for BP on mesocosm research to elucidate the effects of pressure on atomizing spray formation flow of oil that is dispersed at depth.

In July 2010, Dr. Coelho facilitated a Joint Industry Task Force (JITF) Workshop for the American Petroleum Institute (API) to ident ify future areas for research in the fields of dispersants, mechanical recovery, cap and containment, policy, and risk communication research. In 2011, Dr. Coelho became the Program Manager of a JITF to study subsea dispersant injection systems, efficacy, fate and effects, modelling and communication. She is also serving as a subject matter expert on this JITF and drafted an industry paper entitled "Discharging Oil in U.S. Waters to Enhance the Study of Subsurface Dispersant Injections: Field Study Preparat ion and Considerations". She continues to be involved in JITF research coordination with specific emphasis on deep sea dispersion and dissolution of dispersed oil.

Prior to joining EM&A in January 1996, she was a consultant in marine toxicology and enviro nmental project management for Scientific and Environmental Associates, Inc. (SEA). In this capacity, she participated in a number of field and laboratory projects related to the toxicity of crude oil to marine organisms. She also served as a project manag ement consultant for the Marine Spill Response Corporation, during which time she provided oversight on research programs being conducted by

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various US and international research organizations related to evaluating ecological impacts from oil spills.

Dr. Don Aurand is a Subject Matter Expert with more than 40 years of experience in oil spill planning, research, and experimental field design. Dr. Aurand serves as a technical expert on oil spill impacts, dispersant use planning, and ecological risk assessment and risk communication. As a project manager and senior facilitator under previous contracts, Dr. Aurand successfully led nearly 20 Ecological Risk Assessment consensus development workshops related to the environmental effects of oil spill response technologies for the USCG. In addition to his 17-year career with HDR|EM&A, Dr. Aurand has worked as the Director of Environmental Health Research in the MSRC Research and Development Program, served as Program Manager for the Offshore Oil and Gas Environmental Studies Program (US Department of the Interior), and was a Group Leader (Environmental) at the MITRE Corporation. During the latter part of his career, he has focused on issues related to the environmental consequences of oil spills, particularly the role of dispersants. While at MSRC, he developed the concept of using the USEPA ecological risk assessment approach as a tool to develop consensus in oil spill response planning, and later co-authored the Coast Guard guidance manual on conducting consensus ecological risk assessments. After the 1991 Gulf War, he managed and participated in a joint industry-NOAA effort to characterize shoreline oil spill impacts in Saudi Arabia, Kuwait and Iran. Subsequently, he was part of a consulting team which advised the United Nations Compensation Commission on war-related oil spill damage claims.

Dr. Aurand has presented several oil spill response and dispersant use planning courses, including to the USCG (Sector Delaware Bay and District 1), RRT 3 and industry, among others. Dr. Aurand has served as the Secretary of the Potomac Regional Chapter of the Society of Environmental Chemistry and Toxicology (SETAC), where he interacted with members from Federal agencies, state agencies, academia, and the private sector.

During the DWH incident, Dr. Aurand served as Chief Scientist on a number of the oceanographic cruises monitoring the ecological consequences of the deep water dispersant injection. Additionally, he coordinated EM&A's participation by providing Chief Scientists and toxicity testing staff for the cruises. More recently, Dr. Aurand has assisted the Oil Spill Joint Industry Task Force (JITF) under contract to API to examine industry's ability to respond to a "Spill of National Significance (SONS)" based on the actual response to the DWH subsea release, which led to a series of recommendations to the National Commission on the BP DWH Oil Spill and Offshore Oil Drilling (Presidential Commission). He also assisted the JITF in their analysis of the Presidential Commission's final report and the related issue papers to evaluate their potential impact on industry. Dr. Aurand has over 50 technical and peer-reviewed publications related to pollution studies, oil spill response efforts and environmental conflict resolution.

Mr. James Staves joined HDR as a project Scientist in September 2012. He is responsible for providing technical, scientific, and regulatory support to HDR clients, on areas including laws and regulations pertaining to the U.S. National Response System for Oil and Hazardous Substances, chemical dispersant use, and net Environment Benefit Analysis. He has conducted training and workshops on subsea dispersant use, prepared contingency plans required by U.S. regulations for use of subsea dispersants, and participated in several Incident Management Team exercises for HDR client companies operating in

the Gulf of Mexico. He has also performed a comprehensive review of information and resear ch needs to support broader use of Net Environmental Benefit Analyses (NEBA) in the Arctic Circle, and provided technical and administrative support to the API D3 program for advancing the state of science and technology available for subsea dispersant use.

Prior to joining HDR, Mr. Staves spent more than 25 years in the U.S. Environmental Protection Agency where he held positions ranging from Federal On -Scene Coordinator to Co -Chair of the Regional Response Team. He has extensive experience in developing regional programs to implement the emergency prevention, preparedness, and response requirements of the National Environmental Policy Act (NEPA), Clean Water Act (CWA), Comprehensive Environmental Response, Compen sation, and Liability Act (CERCLA), Superfund Amendments and Reauthorization Act (SARA), Oil Pollution Act (OPA), and Clean Air Act (CAA). As an On -Scene Coordinator, he was responsible for Superfund site assessments, Superfund Removal Actions, and on-scene coordination of emergency response actions for accidental releases of oil and hazardous chemicals. He also served as the Agency's representative during emergency response actions for major oil and hazardous chemical spills including the Mega Borg oil spill of 1990, and the Deep Water Horizon incident of 2010. He has held Incident Command System positions ranging from Environmental Unit Leader, to Incident Commander in disasters including Hurricanes Andrew, Katrina, Gustav, and Ike. He has also led mult i-agency teams on Chemical Safety Audits of facilities that had experienced catastrophic hazardous material releases.

During his tenure at the EPA, he served as the first Director for the Emergency Preparedness Center at the University of Texas at Dallas, where he managed technical and administrative staff in developing and promoting the use of innovative information management technologies in the fields of emergency preparedness and response. Mr. Staves was also a Preventive Medicine Officer in the U.S. Army Reserves, and served in Northeastern Saudi Arabia throughout the duration of Operation Desert Storm.

Mr. Eric Miller joined HDR as a Project Scientist in June 2014 after retiring as a commissioned officer with the rank of Commander from the United States Coast Guard (USCG). He is a researcher, program manager, and professional educator possessing over 20 years ' experience leading emergency responses and coordinating interagency and industry roles in protecting the environment and promoting public safety. He possesses extensive operational, policy, and teaching experience in pollution response, environmental protection, and disaster preparedness and recovery. Consequently he is well -versed on United States environmental laws and their regulatory respo nsibilities outlined under the National Oil and Hazardous Substances Pollution Contingency Plan and National Response Framework.

During his tenure with the USCG, he served as a Marine Pollution Investigator, Assistant Professor of Chemistry at the USCG Academy, and as the U.S. Coast Guard's Liaison to the Federal Emergency Management Agency (FEMA). In his last assignment, he served as the Chief of the Industry and Interagency Coordination Division in the Office of the Marine Environmental Response Policy at USCG Headquarters. He was also appointed as the Program Chair for the 2011 and 2014 International Oil Spill Conferences (IOSC) where he led a diverse team of industry, governmental and academic volunteers in developing the technical program for the world 's largest oil spill conference . He is particularly well -versed on the federal government's responsibilities and structures for conducting research and development and technology evaluation for oil spill prevention and response needs based on his

education and experience as the Executive Director for the Interagency Coordination Committee on Oil Pollution Research (ICCOPR).

Ms. Ann Slaughter is a Project Scientist with HDR, and has served as the laboratory manager for HDR's oil and dispersed oil aquatic toxicity testing laboratory since 2006. She holds a BS in chemistry and has more than 25 years of experience in the field of environmental consulting. She was actively involved as a facilitator in a prior Ecological Risk Assessment conducted by HDR for the United States Coast Guard involving a joint effort with the Mexican Navy in the Gulf of Mexico. During the 2010 DWH spill, she served as the lead laboratory supervisor for several dispersant studies and analyses conducted by the company after the United States Environmental Protection Agency directed the re-testing of all dispersants identified on the U.S. National Contingency Plan's Product Schedule. She has also conducted and provided oversight on other Federally-funded and private sector studies related to dispersant, oil, and dispersed oil impacts to marine species.

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Subject: BA - RRT IV
2015_11-05 1045 Dispersant Alternatives.pdf

https://www.nrt.org/sites/52/files/RRT4_BiologicalAssessments_Dispersants&ISB.pdf see Table 2-1

Presentation with toxic date that was presented to RRT 6 (attached)

Clean Gulf Associates

HWCG

Ready to Respond

Alternative Dispersants II

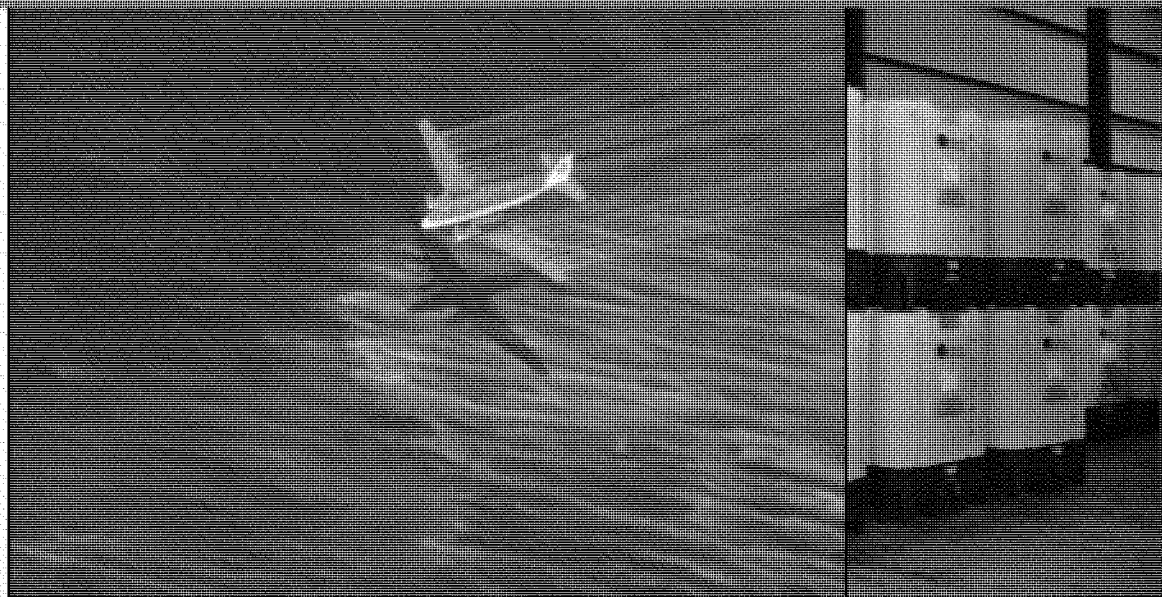
James Hanzalik

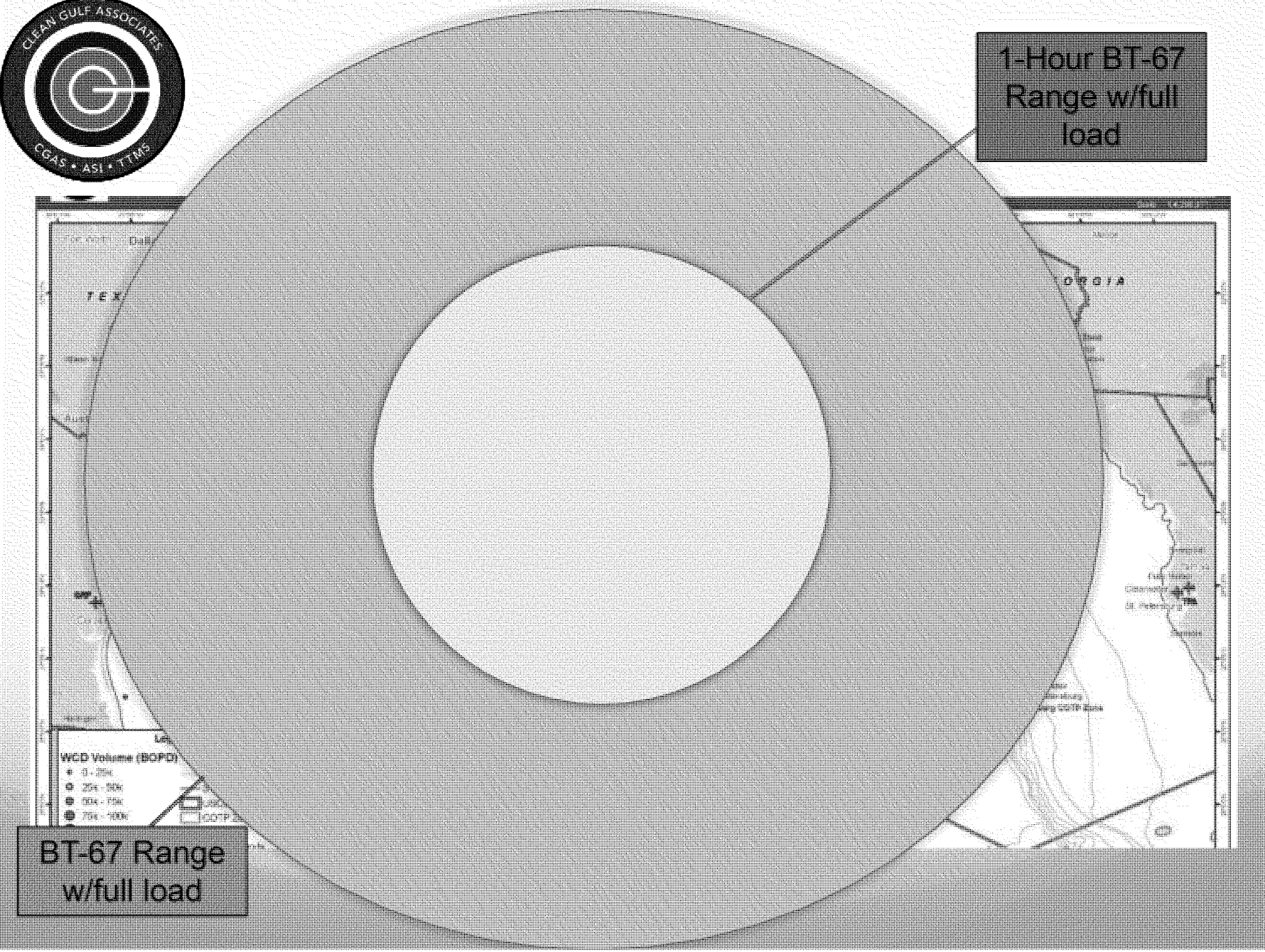
Clean Gulf Associates

* A Not-For-Profit Oil Spill Cooperative
* Formed By 33 Operators in 1972
* "By Industry for Industry"
* Mission focused on Gulf of Mexico Exploration & Production Oil Spill Response
* Currently has 118 Members

Airborne Support, Inc.

- Airborne Delivery Capabilities via Contract with Airborne Support, Inc. (ASI)
- (1) Spotter & (3) Spray Aircraft
- 16K/day application capacity
- 64K gallons of Corexit 9500A co-located at facility




CLEAN GULF ASSOCIATES
CGAS • ASI • TTMS
1-Hour BT-67 Range w/full load
BT-67 Range w/full load
WCD Volume (BOPD)

* HWCG formed in 2011 to meet BSEE requirements for Deep Water drilling.
* Mission focused on Well Containment for U.S. Gulf of Mexico.
* HWCG has 16 Members
* HWCG has all the necessary equipment to support subsea dispersant operations.

Goals

* Joint Venture by CGA and HWCG for the last three years
* Identify for use an alternative dispersant to Nalco Corexit products
* Have an inventory of equally effective dispersant with less toxicity
* Educate RRT VI & IV and FOSCs alternative dispersant solutions
* Alternative(s) selected and stocked in limited quantities available for aerial and subsea use
* FOSC is free to use dispersants without an indemnification from the manufacturer or cooperatives

Product Selection Criteria

* EPA Subpart J Product Schedule
* Effective on Louisiana light sweet crude
* Similar toxicity to Corexit
* Additional Testing (e.g., EXDET, OHMSETT, others)
* Manufacturing capacity and product turnaround
* No Indemnification requirement for product use

Dispersant Testing Status

Dispersant	Toxicity (C50 values in ppm) W/No 2 Fuel oil		Effectiveness (%)		
	Menidia (96-hr)	Mysidopsis (48-hr)	Prudhoe Bay Crude Oil	South Louisiana Crude Oil	Average of Crude Oils
BIODISPERS	5.95	2.66	51.00	63.00	57.00
COREXIT® EC9500A	2.61	3.40	45.30	54.70	50.00
FINASOL OSR 52	5.40	2.37	32.50	71.60	52.10
Accell Clean ® DWD	8.05	1.32	58.70	96.03	77.36
JD-2000™	3.59	2.19	60.40	77.80	69.10
Marine D-Blue Clean	32.00	18.00	45.00	55.59	50.30
SUPERSPERSE™ WAO2500	3.70	2.53	77.84	87.56	82.70

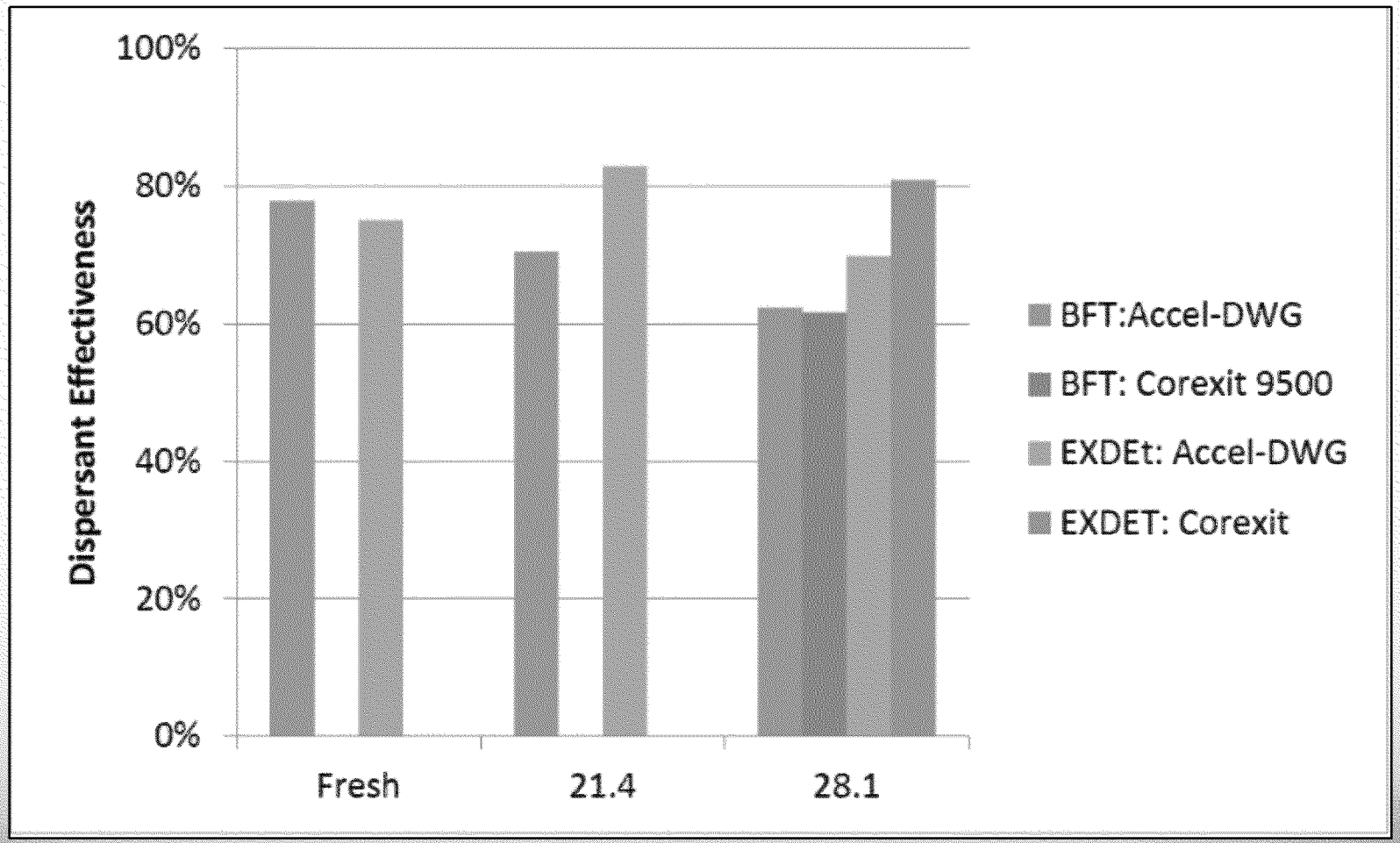
Source: EPA Product Schedule

Dispersant Effectiveness (EXDET)

Dispersant	Replicate	1	2	3	4	Average
Accel-DWG	Fresh	69.6	76.9	77.9	75.7	**75.0**
	21.4%	79.9	86.8	81.5	83.1	**82.8**
	28.2%	72.7	52.1	72.8	81.7	**69.8**
Corexit 9500	28.2%	84.5	76.8			**80.7**

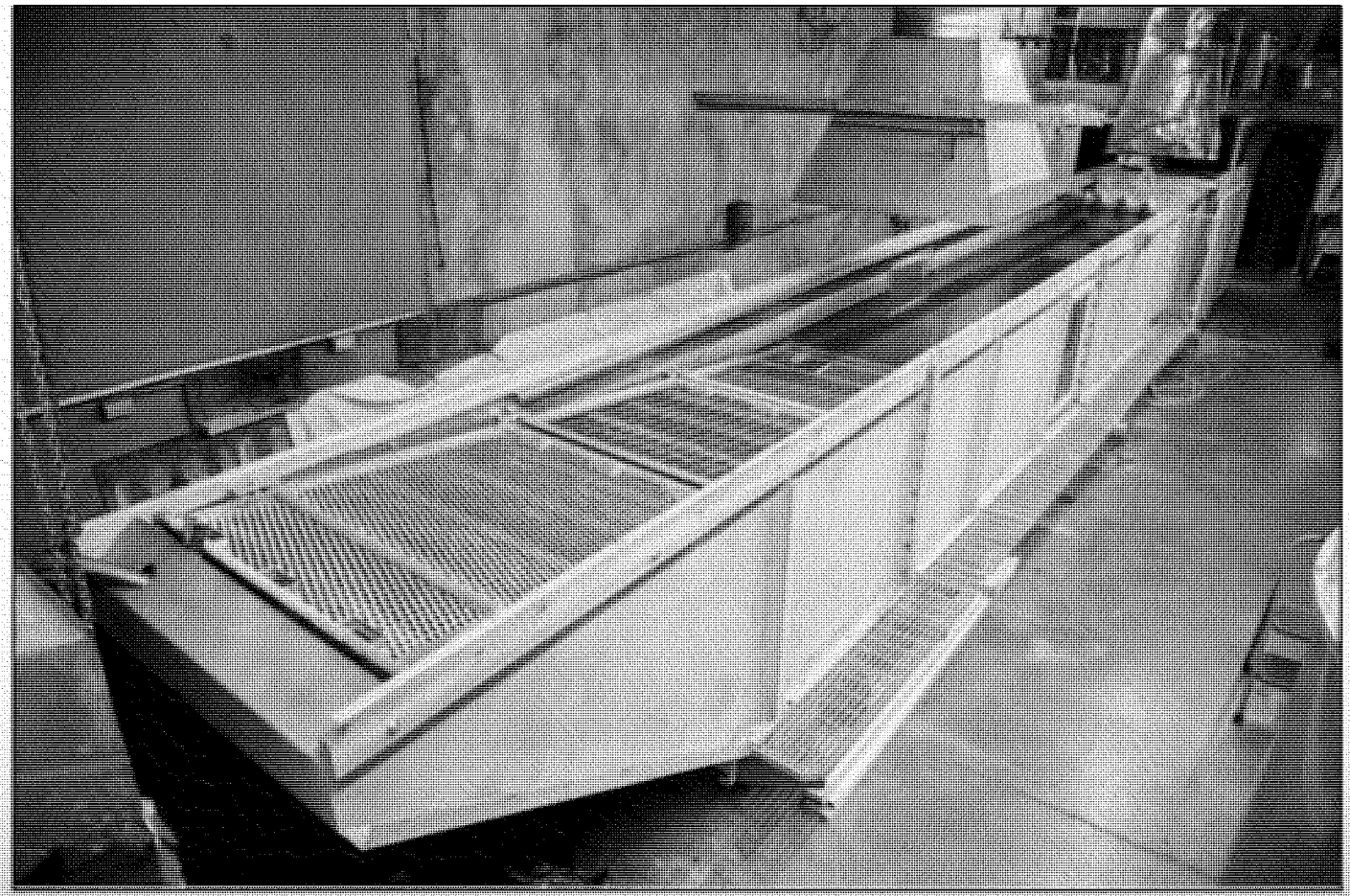
S.L Ross, 2015

Dispersant Effectiveness (EXDET)



S.L Ross, 2015

Dispersant Effectiveness
(MESO Scale Wave Tank)



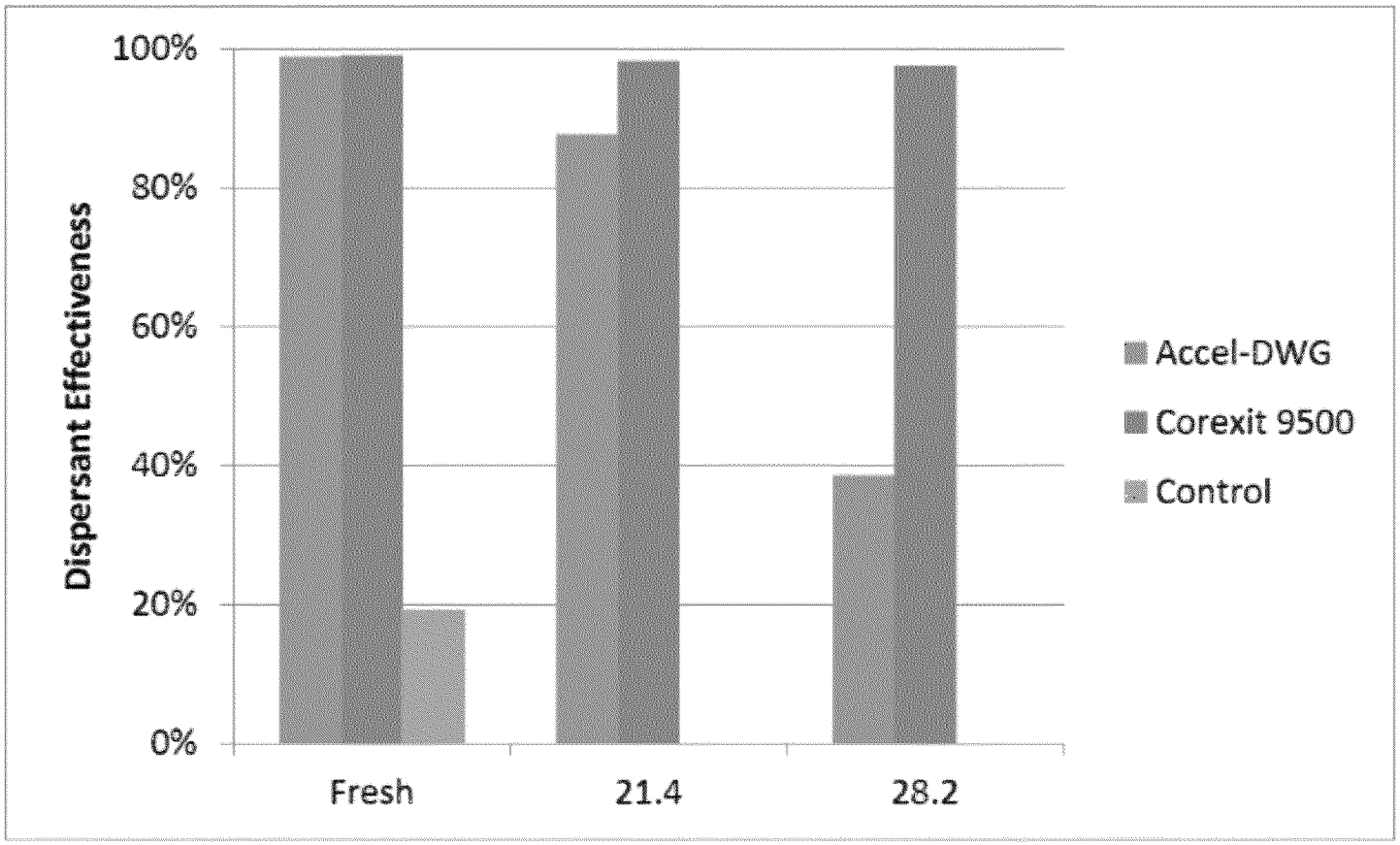
S.L Ross, 2015

Dispersant Effectiveness
(MESO Scale Wave Tank)

Dispersant	Fresh	21.4%	28.1%
Accel-DWG	98.8	87.7	38.6
Corexit 9500	99.1	98.2	97.6
Control	19.1		

S.L Ross, 2015

Dispersant Effectiveness
(MESO Scale Wave Tank)



S.L Ross, 2015

Dispersant Toxicity
(NCP Tests)

Material Tested	Species	LC50 (ppm)
ACCELL CLEAN® DWD	Menidia beryllina Mysidopsis bahia	6.58 96-hr 1.55 48-hr
No. 2 Fuel Oil	Menidia beryllina Mysidopsis bahia	38.0 96-hr 3.61 48-hr
ACCELL CLEAN® DWD & No. 2 Fuel Oil (1:10)	Menidia beryllina Mysidopsis bahia	4.21 96-hr 2.21 48-hr
Reference Toxicant (Sodium Dodecyl Sulfate – SDS)	Menidia beryllina Mysidopsis bahia	2.43 96-hr 5.95 48-hr

Environmental Enterprises USA (EE USA) Toxicity Data for Accell Clean® DWD (2015)

Dispersant Toxicity
(NCP Tests)

Material Tested	Species	LC50 (ppm)
ACCELL CLEAN® DWD	Menidia beryllina Mysidopsis bahia	5.66 96-hr 2.07 48-hr
No. 2 Fuel Oil	Menidia beryllina Mysidopsis bahia	11.10 96-hr 1.68 48-hr
ACCELL CLEAN® DWD & No. 2 Fuel Oil (1:10)	Menidia beryllina Mysidopsis bahia	8.05 96-hr 1.32 48-hr
Reference Toxicant (DDS)	Menidia beryllina Mysidopsis bahia	6.60 96-hr 30.80 48-hr

Retrieved from http://www2.epa.gov/emergency-response/accell-cleanr-dwd

Accell Clean ® DWD

* Listed on EPA Subpart J Product Schedule (2011)
* Very effective on Louisiana light sweet crude (E&P crude)
* Similar toxicity to Corexit
* Positive Results EXDET, Meso-scale (BSEE to test at OMSETT)
* 30K gallons/day manufacturing capacity 5-7 days
* <u>No Indemnification</u> for product use
* Protein-based Dispersant

CGA/HWCG Actions

* Agreement finalized between Advanced BioCatalytics, Corp. (ABC), CGA and HWCG
* CGA is planning to stock approximately 5K gallons at Airborne Support in Houma, LA.
* Dispersant will be available for “Spills of Opportunity”

Questions?

To: Principe, Vanessa[Principe.Vanessa@epa.gov]; Matthiessen, Craig[Matthiessen.Craig@epa.gov]
From: Wilson, Gregory
Sent: Wed 3/16/2016 10:37:00 PM
Subject: RE: REQUEST TO CHAT - RE: MEPC 69/20/2 Position Papers
RE: IMO Subsea Dispersant Meeting, May 13th, 2015
IPIECA Dispersants: Subsea Use Draft Guidance / in Preparation for IMO Subsea Guidance Meeting

We had raised concerns with USCG on the IPIECA GPG during previous calls. My recollection was that IPIECA did not want to edit their document to address our concerns, so I don't think that we should be seen as "providing credibility" to their documents. I agree with Vanessa on the concerns she provided below.

From: Principe, Vanessa
Sent: Wednesday, March 16, 2016 6:05 PM
To: Matthiessen, Craig <Matthiessen.Craig@epa.gov>; Wilson, Gregory <Wilson.Gregory@epa.gov>
Subject: REQUEST TO CHAT - RE: MEPC 69/20/2 Position Papers

In Spring-Summer 2015 a USCG WG was leading the effort to develop a subsea dispersant guidance as the U.S. delegation's contribution to a UN-IMO publication on spill response. An option on the table was to consider adopting IPIECA's draft Good Practice Guidance (GPG) titled Dispersants: Subsea Application in lieu of developing a subsea guidance from scratch.

We attended a few meetings and reviewed the draft IPIECA GPG. We had overarching concerns with their approach to NEBA and some very general statements and scientific "conclusions" (on fate and transport, exposures, damages), and thought we should be very careful agreeing to adopt it as a government product. **We were going to recommend not to adopt the IPIECA document.** The effort was put on hold and until this USCG request; **this time the effort is much broader in scope**.

The U.S. delegation is now considering not only the subsea dispersant GPG, but a set of 24 oil spill response GPGs for IMO joint publication. What are seen as the benefits of having IMO-IPIECA joint publications (reaching a wider audience; adding to their credibility; often used as industry standards) may pose issues for us if these GPGs are making statements that are contrary to U.S. regulations and/or policy. The request is for feedback on overall concerns or "show stoppers."

After comparing the final subsea dispersant GPG (#7 of the list of 24 they provided) with the 2015 draft previously reviewed, the same concerns stand. Perhaps even more so as they have now strengthened some arguments that we take issue with (e.g., NEBA assessment skewed towards shoreline protection, subsea dispersant use to control VOC for worker health/safety, oil dispersed in the water column biodegrades in days to weeks). This GPG also cites a report entitled Regulatory approval of dispersant products and authorization for their use (IPIECA-IOGP Oil Spill Response JIP 2014), which contains some statements that we have issues with. For example, it argues that subsea dispersant use "reduces the concentration of volatile organic compounds (i.e. BTEX compounds) reaching the air, thereby reducing the explosion risk and the potential inhalation hazard to responders working on the surface to cap the well." Also argues "It can take years to decades for some shoreline communities to recover from oiling, whereas many water-column communities recover in weeks to months." This last statement can be seen as in conflict with the DWH NRDA findings relative to the water column damage assessment. [Attached is the original set of comments with some notes starting to cross-reference the final GPG, and some statements from the cited regulatory report at the end.]

While the request is not to comment or edit each document, some of the documents included are likely to contain references and statements relative to our policy/regulatory requirements. I would argue that will necessitate their review prior to being adopted with U.S. government blessing, at least from EPA's standpoint. Notable are:

4. Economic assessment and compensation for marine oil releases

6. Dispersants: surface application

10. Incident management system for the oil and gas industry

11. Oil spills: inland response

12. Response strategy development using net environmental benefit analysis (NEBA)

22. In situ burning of spilled oil

The alternative recommendation is for a drafting group to review these further before deciding. Two concerns. First and foremost, that is a big haul and we just do not have the resources. Second, adopting documents developed by an industry trade group (IPIECA's membership includes 36 oil companies and 16 associations, representing over 400 oil and gas companies) may pose similar issues to those we just dealt with regarding the API OSRP Recommended Practice document. Unclear how the U.S. as a "Member State" of this United Nations "specialized agency" would be required to have its Agencies/Departments abide

by/incorporate/be consistent with any IMO publication. That would need to be raised to OGC.

Trying to avoid us having to defend ourselves from statements we don't agree with but that end up being blessed by the U.S. thru IMO. Would like to chat on how to proceed.

Thanks!

V

-----Original Message-----
From: Ottenwaelder, Thomas A CDR [mailto:Thomas.A.Ottenwaelder@uscg.mil]
Sent: Wednesday, March 16, 2016 1:08 PM
To: Paul Lattanzi <plattanzi@cep.unep.org>; Sligh, Kevin M CIV <Kevin.M.Sligh@uscg.mil>; Eric Miller <eric.miller@bsee.gov>; Aten, Brandon J LT <Brandon.J.Aten@uscg.mil>; Scott.A.Stoermer@uscg.mil; trisha.bergmann@noaa.gov; mark.dix@noaa.gov; Maghini, Monica K CIV <Monica.K.Maghini@uscg.mil>; Weaver, James (USCG) <James.D.Weaver@uscg.mil>; 'john.caplis@bsee.gov' <john.caplis@bsee.gov>; Principe, Vanessa <Principe.Vanessa@epa.gov>; Matthiessen, Craig <Matthiessen.Craig@epa.gov>; Wilson, Gregory <Wilson.Gregory@epa.gov>
Cc: Loring, Joseph B CAPT <Joseph.B.Loring@uscg.mil>
Subject: MEPC 69/20/2 Position Papers

Good Afternoon,

The Attached Position Paper was submitted to IMO by IOGP and IPIECA for the U.S. delegation's consideration. In short, the IOGP and IPIECA developed 24 good practice guides that cover oil spill response and they would like these guides considered for IMO joint publication. The benefits of IMO joint publication are that their guides will reach a wider audience and add to their credibility. More detailed information can be found in the attached IMO Position Paper, as well as their website http://oilspillresponseproject.org website. These 24 guides are readily available publications and often used as industry standards.

We respectfully request you assistance reviewing the attached position paper, along with associated documents. Please provide your recommendation as to whether this is something the U.S. could support. There is no need to comment or edit each document. We are interested in whether or not there are any overall concerns or "show stoppers". For example; Does one of these documents conflict with other IMO policies or good practices? Should we support the idea in concept and recommend a drafting group to review these further before we decide?

Feel free to pass this along to another person in you agency if you wish. Please provide your input directly to me by 31 March. I am available anytime if you have any questions or concerns. Semper Paratus!

v/r,

CDR Tom Ottenwaelder

U.S. Coast Guard, Office of Marine Environmental Response International & Domestic Preparedness Division (MER-2)

office: 202-372-2264

mobile: 443-684-3814

thomas.a.ottenwaelder@uscg.mil

To: Matthiessen, Craig[Matthiessen.Craig@epa.gov]
Cc: Wilson, Gregory[Wilson.Gregory@epa.gov]
From: Principe, Vanessa
Sent: Mon 7/27/2015 6:33:42 PM
Subject: IPIECA Dispersants: Subsea Use Draft Guidance / in Preparation for IMO Subsea Guidance Meeting
IPIECA_Dispersants_Subsea Use _OEM_7_27_15.docx

FYI – Attached are our comments on the IPIECA draft guidance that the workgroup wanted to consider adopting as IMO Subsea Guidance.

We have overarching concerns with the guidance's approach to NEBA, and with some very general statements and scientific "conclusions" that we should be very careful agreeing to as part of a government product. We will be recommending that we do not adopt this document.

V

To: Wilson, Gregory[Wilson.Gregory@epa.gov]; Matthiessen, Craig[Matthiessen.Craig@epa.gov]; DeHaven, Leigh[DeHaven.Leigh@epa.gov]
From: Principe, Vanessa
Sent: Thur 6/18/2015 8:34:00 PM
Subject: RE: IMO Subsea Dispersant Meeting, May 13th, 2015
IPIECA_Dispersants_Subsea Use__VP2.docx

All:

We didn't get to chat with LT Aten today. However, expect that if he did have his meeting with the IMO contact today, over the next few we might get an invite to discuss the IPIECA April 2015 DRAFT Dispersants: Subsea Use Guidance, and whether we should consider using it in developing the IMO subsea guidance.

Here is a revised draft of comments/issues that I see of concern. The draft has guidance language excerpts (by page) that caught my eye, and comments for each.

Take a look and see if you want to add/delete/amend any of my takes. Thought this could be something we can use to send over our comments/concerns with adopting the IPIECA document.

V

-----Original Message-----
From: Aten, Brandon J LT [mailto:Brandon.J.Aten@uscg.mil]
Sent: Wednesday, June 17, 2015 4:40 PM
To: Principe, Vanessa
Cc: Wilson, Gregory; Matthiessen, Craig; DeHaven, Leigh
Subject: RE: IMO Subsea Dispersant Meeting, May 13th, 2015

Hey Vanessa,

-Just a quick update

Meeting was pushed until tomorrow at 1100 with Ms. O'Hagan from IMO. Do you have time to briefly talk tomorrow morning before 1100? I would be interested in hearing your concerns if you have time. As mentioned before, after the meeting tomorrow I will send an update out to the group on what was discussed and the way forward.

-Brandon

Very Respectfully,

LT Brandon Aten
United States Coast Guard
Office of Marine Environmental Response Policy
W: 202-372-2248
C: 860-514-4581
Brandon.J.Aten@uscg.mil

-----Original Message-----
From: Principe, Vanessa [mailto:Principe.Vanessa@epa.gov]
Sent: Wednesday, June 17, 2015 9:57 AM
To: Aten, Brandon J LT

Cc: Wilson, Gregory; Matthiessen, Craig; DeHaven, Leigh
Subject: RE: IMO Subsea Dispersant Meeting, May 13th, 2015

Good. Had some concerns regarding the IPIECA document and wanted to make sure I had not missed the opportunity to bring those up.

I'll be on the lookout for the update. Thanks! V

-----Original Message-----
From: Aten, Brandon J LT [mailto:Brandon.J.Aten@uscg.mil]
Sent: Wednesday, June 17, 2015 9:46 AM
To: Principe, Vanessa
Cc: Wilson, Gregory; Matthiessen, Craig; DeHaven, Leigh
Subject: RE: IMO Subsea Dispersant Meeting, May 13th, 2015

Good morning Vanessa,

You have not missed anything, we have a meeting with Colleen O'Hagan from the IMO today at 1600 and, after that meeting, I plan to send out an update. (To include the way forward as Mr. Lundgren is transitioning to a new job at NOAA next month)

Please let me know if you have any questions and I'll be in touch later today.

Respectfully,

Brandon Aten

-----Original Message-----
From: Principe, Vanessa [mailto:Principe.Vanessa@epa.gov]
Sent: Wednesday, June 17, 2015 9:11 AM
To: Aten, Brandon J LT
Cc: Wilson, Gregory; Matthiessen, Craig; DeHaven, Leigh
Subject: RE: IMO Subsea Dispersant Meeting, May 13th, 2015

Good morning:

Checking I have not missed any communications regarding this effort. Last information I found was for a June 3rd meeting (tentative), with a discussion beforehand of the IPIECA document.

Thanks, V

From: Aten, Brandon J LT [mailto:Brandon.J.Aten@uscg.mil]
Sent: Wednesday, May 13, 2015 4:26 PM
To: 'john.caplis@bsee.gov'; 'timothy.steffek@bsee.gov'; 'carl.childs@noaa.gov'; michael.k.sams@uscg.mil; Lundgren, Scott; Faulkner, Mike; Principe, Vanessa; Tulis, Dana; Matthiessen, Craig; Wilson, Gregory; DeHaven, Leigh; Jozsef, Aaron L LT; brwalker@fs.fed.us
Subject: IMO Subsea Dispersant Meeting, May 13th, 2015

(Switch to HTML)

Good afternoon,

Thanks for everyone's participation and feedback during the meeting this afternoon. I realize after our last meeting on April 29th I did not send out a recap, so I apologize to those who were catching up this week without a proper brief.

Recap from the meeting: 1500-1530, May 13th, 2015

References: Drop-box link for all the references will not work for every agency. Google Drive also only partially works for all agencies involved. I will either conduct a specific solution for each agency depending on their IT infrastructure or find a better option potentially through SharePoint. Furthermore, it was requested to add all the relevant parts (particularly parts 1 and 2) of the IMO Dispersant Guidelines to the reference section, as only part 3 has been made available to some of the members.

The proposed Fate and Effects section was removed for its previous standalone position as it can be touched upon in several proposed sections, specifically, sections 2, 3, and 5 of the draft outline below.

General guidance dictates a 15-20 page product, but we are not restricted to that amount.

LT Brandon Aten will catch up new members, Ms. Belinda Walker and LT Aaron Jozsef and anyone else who would like more background on this initiative.

Mr. Scott Lundgren briefly reviewed the new subsea dispersant document from IPIECA. (IPIECA-http://www.ipieca.org/about-us <http://www.ipieca.org/about-us>) This document was attached to my email sent, May 13th @ 1332 (labeled: Subsea Dispersant GPG_17 April 2015). Considering that we (USCG) had just received this document on Tuesday, we just provided a general overview of their initiative and coverage of the subsea dispersant topic. Mr. Scott Lundgren stated that a possibility exists in which we could review the document and, if deemed acceptable by the group, include it as a joint document. Nevertheless, Mr. Scott Lundgren will check with IPIECA to see if we are able to comment on the existing document. The group concluded that closely reviewing this document over the next 7-10 days would be beneficial to see if we should move forward with this document, comment and make changes if able, or move forward with a separate independent document.

Action Items:

Resolve Reference Situation (COB 15 May) ? LT Aten

Add parts 1 and 2 of the IMO Dispersant Guidelines- LT Aten

Over the next 7-10 days, review the IPIECA document ('Dispersants: Subsea Use'). ?IMO US Team

Continue pondering about the outline below and send suggestions to LT Brandon Aten- IMO US Team

If desired, volunteer to complete the initial draft of a section below - IMO US Team

Next Meeting Tentatively scheduled for June 3rd at 1500. However, we will most likely have a meeting beforehand to discuss the IPIECA document. I will send out an email with potential timeframes (for next week or early the following week)

Thanks again! I hope you all have a wonderful week.

IMO US Team- Subsea Dispersant Outline

1. Intro (LT Aten, Mr. Lundgren)

- Describe the role of subsea dispersion within the overall strategy of a response to a subsea oil release.

2. Role in Response Strategies/Conditions for Use (EPA / NOAA / USCG / BSEE)

- Advantages/disadvantages/conditions when Sub Sea dispersion is advisable as opposed or in addition to other response strategies? Would it include discussion of physical/chemical/mechanism of action?

- General discussion of the advantages and disadvantages of using subsea dispersants, and under what type of conditions it might be a suitable response option to implement

- Fate and Effects?

3. Decision-Making Procedures (EPA / USCG / NOAA / BSEE / USDA)?

- Tradeoff assessment considered to inform the determination to use this strategy, and as part of the authorization request process? Not sure that "conditions of use" would not be part of the authorization process, which I understand would establish use parameters on a case-by-case basis.

- There could be a discussion on the concepts involved with the process of decision-making and approval, including pre-incident planning, decision-making for initial dispersant usage, and for continued day-to-day operational decision-making as new information is presented (ie results of monitoring, etc). I would mention NEBA as a process that should be used to inform decision-making at all three steps, but I would not try to address the details of the various conditions that would be considered in the NEBA (probably too much detail).

- Fate and Effects?

4. Operations (BSEE / USCG / USDA)

- Describe the main features of the various specialized equipment available in the world today as well as the logistical requirements related to mobilization and deployment of this equipment;

5. Monitoring -Carl Childs, NOAA (EPA / USCG / USDA)

- Describe methodologies for operational monitoring and control of a subsea dispersion operation;

- Fate and Effects?

6. Data and Information Management -LT Aten, USCG (USCG / EPA)

- Internal and external communications

Very Respectfully,

LT Brandon Aten

USCG, MER-1

W: 202-372-2248

C: 860-514-4581

Brandon.J.Aten@uscg.mil

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To: Craig Matthiessen[Matthiessen.Craig@epa.gov]
Cc: Mace Barron[Barron.Mace@epa.gov]; Principe, Vanessa[principe.vanessa@epa.gov]
From: Wilson, Gregory
Sent: Wed 1/13/2016 6:03:41 PM
Subject: FW: spoke with Drew Landry....can I send him this presentation?
Barron dispersant tox.pdf

Craig –

See below. Mace got this request below.

From: Barron, Mace
Sent: Wednesday, January 13, 2016 12:47 PM
To: Robbins, Chris <Robbins.Chris@epa.gov>; Scaggs, Ben <Scaggs.Ben@epa.gov>
Cc: Raimondo, Sandy <Raimondo.Sandy@epa.gov>; Wilson, Gregory <Wilson.Gregory@epa.gov>
Subject: spoke with Drew Landry....can I send him this presentation?

Greg, putting you in the loop.

All I know is Drew is from Louisiana and is doing a documentary on the oil spill, and was interested in talking with someone in EPA about dispersants off camera. Chris and Ben asked me to speak with him; they could better explain the context of what he is doing and who he is.

I just gave him a lay person overview of dispersant ecotox, explained that other Agencys deal with worker safety issues of dispersants, cleared up some of his misconceptions about how dispersants are listed (not approved) by EPA, and what are some of the tradeoffs considered in spill response. I also told him that the intention of aspects of the proposed new rule for Subpart J were to list less toxic and more effective dispersants, which was a big concern of his. He seemed to be happy and more informed.

He asked if I would send him some links to dispersant information.

Can I send him the attached? It is public domain already, as I presented it to the US Coast Guard a month ago, and it is posted on a NOAA Sea Grant site (not sure where).

He is visiting DC right now, and asked if there was someone he could interview on camera.

His email is: drewlandry@yahoo.com; cell: 3373269722.

Sincerely,

Mace

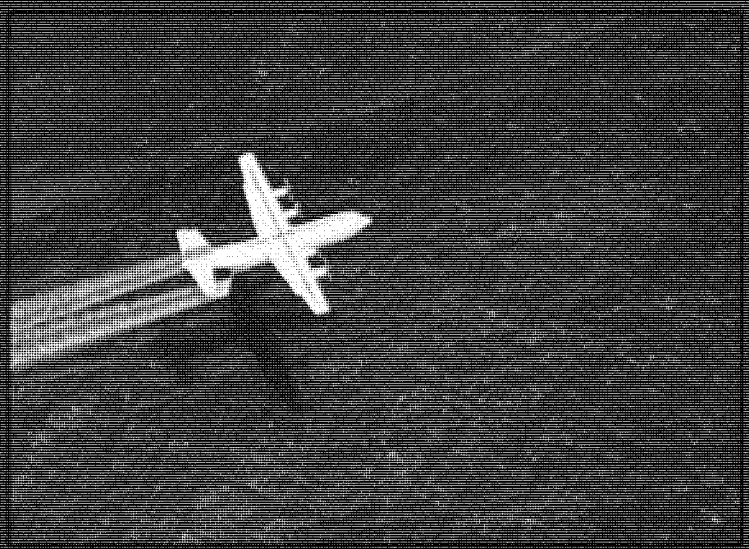
EPA
United States
Environmental Protection
Ag

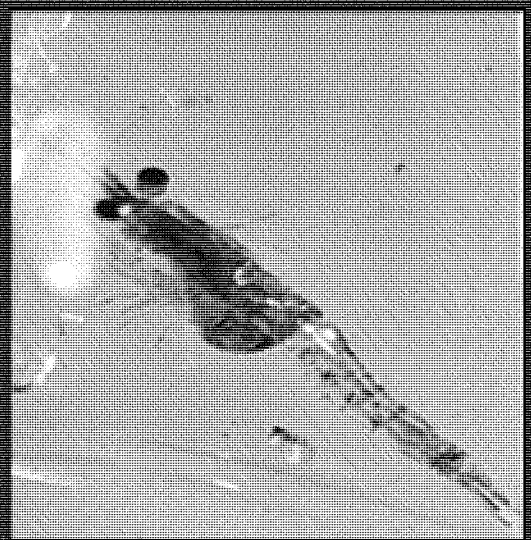
Dispersant Toxicology

Efficacy and Effects

Mace Barron

USEPA Office of Research and Development

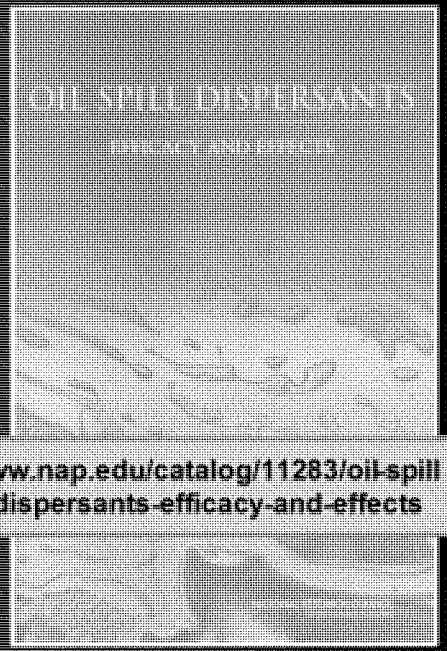




Office of Research and Development
NHEERL, Gulf Ecology Division, Gulf Breeze, FL 32561

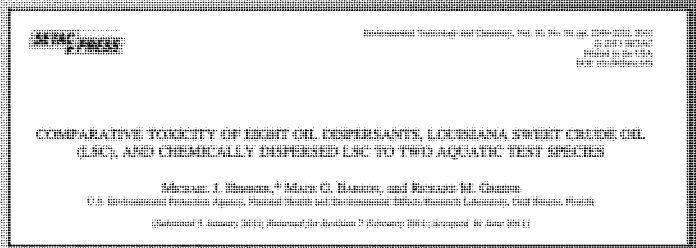
Outline

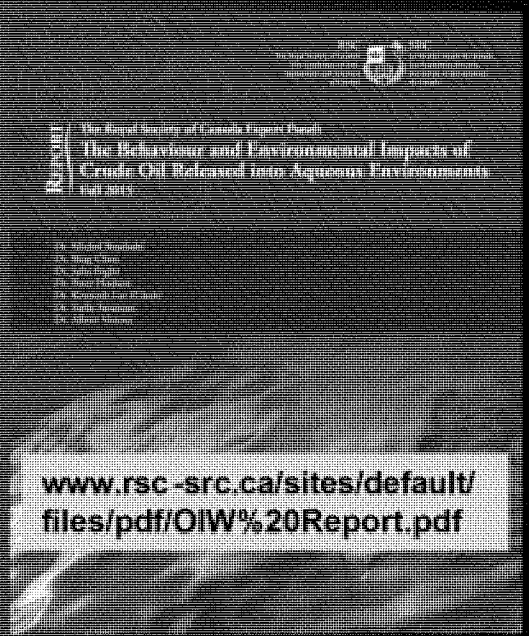
- Overview of oil spill dispersant efficacy and effects
- EPA dispersant testing program
- Implications for spill response

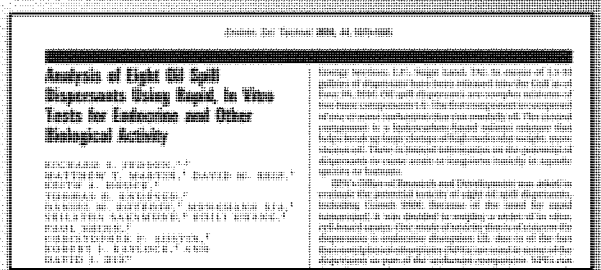


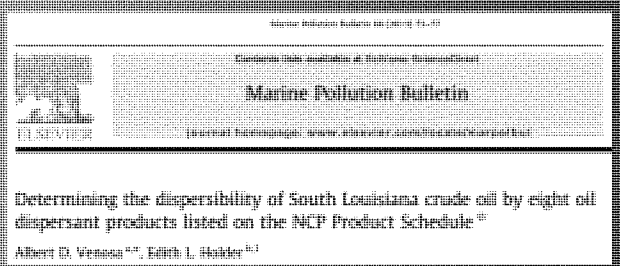
www.nap.edu/catalog/11283/oil-spill-dispersants-efficacy-and-effects

- Background Reports:
- NRC (2005) oil spill dispersant efficacy and effects
- RSC (2015) Canada expert report on oil behavior and impacts
- EPA journal articles on dispersant testing





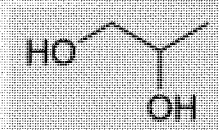


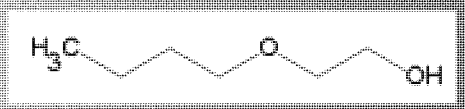


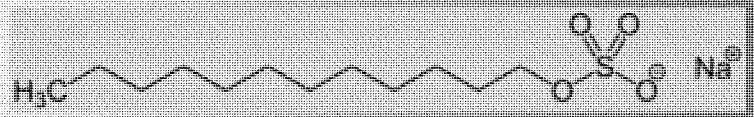
www.rsc-src.ca/sites/default/files/pdf/OIW%20Report.pdf

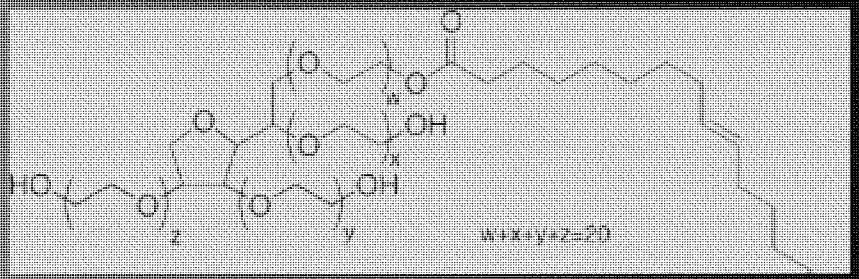
What is a dispersant?

- Many products, varied components
- proprietary formulations of surfactants, light petroleum, solvents









- break oil into tiny droplets
- facilitates biodegradation, dilution
- effective on <30% weathered oil
- moves oil from slick into the water column
- tradeoff between surface/shoreline impacts and water column effects
- increased toxicity to aquatic organisms below the surface

Corexit MSDS

www.nalcoesllc.com/nes/documents/MSDS/NES-LLC-COREXIT-EC9500A-March_2012.pdf

NALCO Environmental Solutions LLC

SAFETY DATA SHEET

PRODUCT

COREXIT® EC9500A

EMERGENCY TELEPHONE NUMBER(S)
(800) 424-9300 (24 Hours) CHEMTREC

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

PRODUCT NAME :	**COREXIT® EC9500A**
APPLICATION :	OIL SPILL DISPERSANT
COMPANY IDENTIFICATION :	Nalco Environmental Solutions LLC 7705 Highway 90-A Sugar Land, Texas 77478
EMERGENCY TELEPHONE NUMBER(S) :	(800) 424-9300 (24 Hours) CHEMTREC

NFPA 704M/HMIS RATING
HEALTH : 2 / 2 FLAMMABILITY : 1 / 1 INSTABILITY : 0 / 0 OTHER :
0 = Insignificant 1 = Slight 2 = Moderate 3 = High 4 = Extreme * = Chronic Health Hazard

2. COMPOSITION/INFORMATION ON INGREDIENTS

Our hazard evaluation has identified the following chemical substance(s) as hazardous. Consult Section 15 for the nature of the hazard(s).

Hazardous Substance(s)	CAS NO	% (w/w)
Distillates, petroleum, hydrotreated light	64742-47-8	10.0 - 30.0
Propylene Glycol	57-55-6	1.0 - 5.0
Organic sulfonic acid salt	Proprietary	10.0 - 30.0

www.nalcoesllc.com/nes/documents/MSDS/NESLLC - COREXIT-_EC9527A-March_2012.pdf

NALCO Environmental Solutions LLC

SAFETY DATA SHEET

PRODUCT

COREXIT® EC9527A

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NFPA 704M/HMIS RATING
HEALTH : 2 / 2* FLAMMABILITY : 1 / 1 INSTABILITY : 0 / 0 OTHER :
0 = Insignificant 1 = Slight 2 = Moderate 3 = High 4 = Extreme * = Chronic Health Hazard

2. COMPOSITION/INFORMATION ON INGREDIENTS

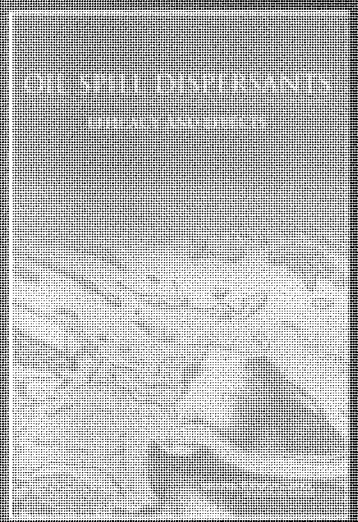
Our hazard evaluation has identified the following chemical substance(s) as hazardous. Consult Section 15 for the nature of the hazard(s).

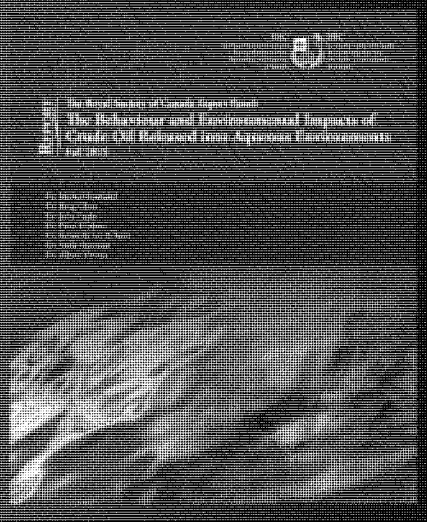
Hazardous Substance(s)	CAS NO	% (w/w)
2-Butoxyethanol	111-76-2	30.0 - 60.0
Organic sulfonic acid salt	Proprietary	10.0 - 30.0
Propylene Glycol	57-55-6	1.0 - 5.0

- similar composition; 9500A contains light petroleum distilates
- lab tests show similar toxicity and efficacy

Principles of Dispersant Toxicology

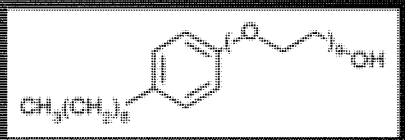
- intrinsic toxicity of oil does not increase
- moderately toxic and much less toxic than oil
- chemically dispersed oil similar toxicity as physically dispersed oil
- increase the concentration of oil in the water column
- greater bioavailability to aquatic life
- reduce risks to shorelines and surface species
- increased risk to subsurface species (top 30 feet of water column)
- impacts to sub-surface resources less obvious



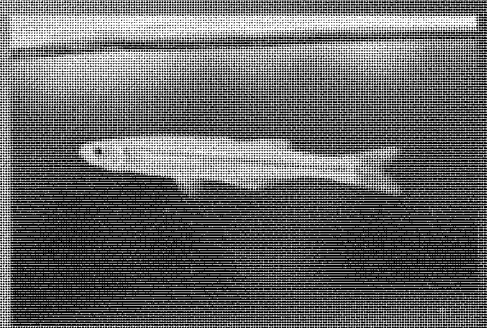


EPA 2010 DWH Testing Program

- Test 8 dispersants on NCP Product Schedule:
  - Identify lower toxicity alternatives (EPA Administrator)
  - Verify information on NCP Product Schedule
  - Test Louisiana crude oil (SLC) instead of fuel oil #2
  - Concerns for nonylphenol ethoxylate degradation

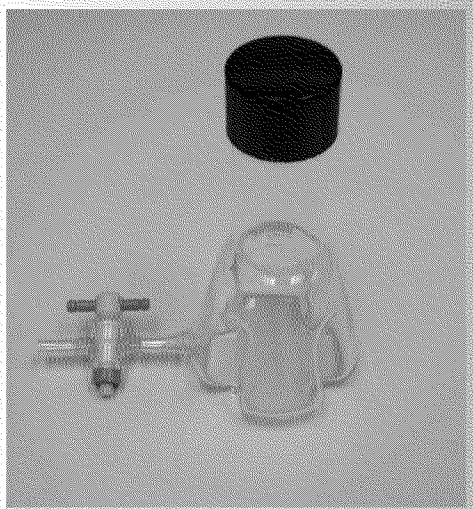


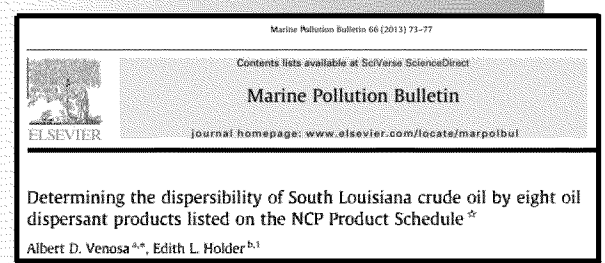
- Laboratory testing program:
  - Efficacy of oil+dispersant
  - In vitro endocrine and cytotoxicity screening
  - Acute toxicity to two Gulf estuarine species
    - dispersant alone; SLC oil+dispersant



Lab Determination of Dispersant Effectiveness

- Baffled Flask Test (BFT) at 41 and 77 °F with SLC oil
- 3 of 8 satisfactory dispersion results (>70% efficacy)
- similar results at cold and warm temperatures SLC
- Corexit 9500A 75-80% lab dispersion





Marine Pollution Bulletin 66 (2013) 73–77

Contents lists available at SciVerse ScienceDirect

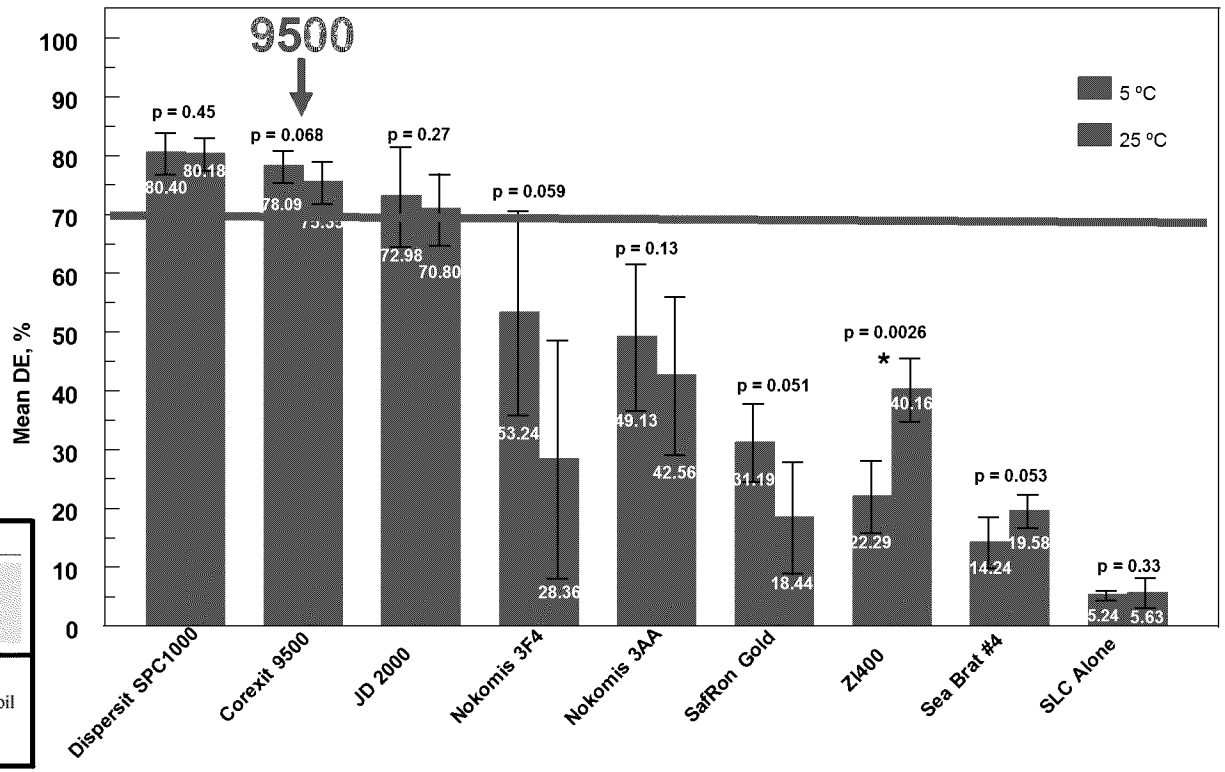
Marine Pollution Bulletin

journal homepage: www.elsevier.com/locate/marpolbul

ELSEVIER

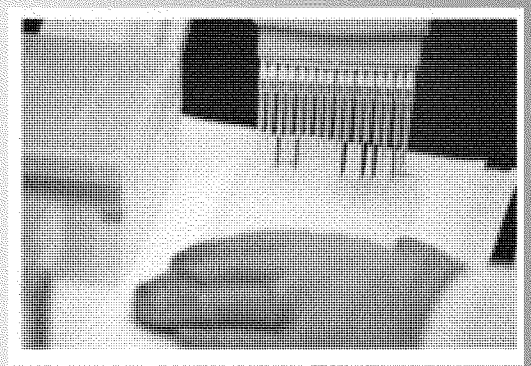
Determining the dispersibility of South Louisiana crude oil by eight oil dispersant products listed on the NCP Product Schedule ☆

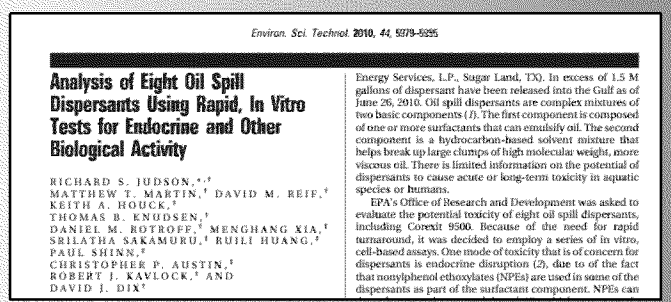
Albert D. Venosa [a,*], Edith L. Holder [b,1]



Cytotoxicity and Endocrine Screening

- only test dispersants (no oil)
- *in vitro* testing using 80 mammalian cell line assays
- determine cell death, estrogen and androgen receptor activity
- dispersant only: tested at concentrations up to 10,000 ppm
- similar results in all 8 dispersants
- no estrogenic or androgenic activity detected at 10,000 ppm
- test tube cell death above 10 ppm





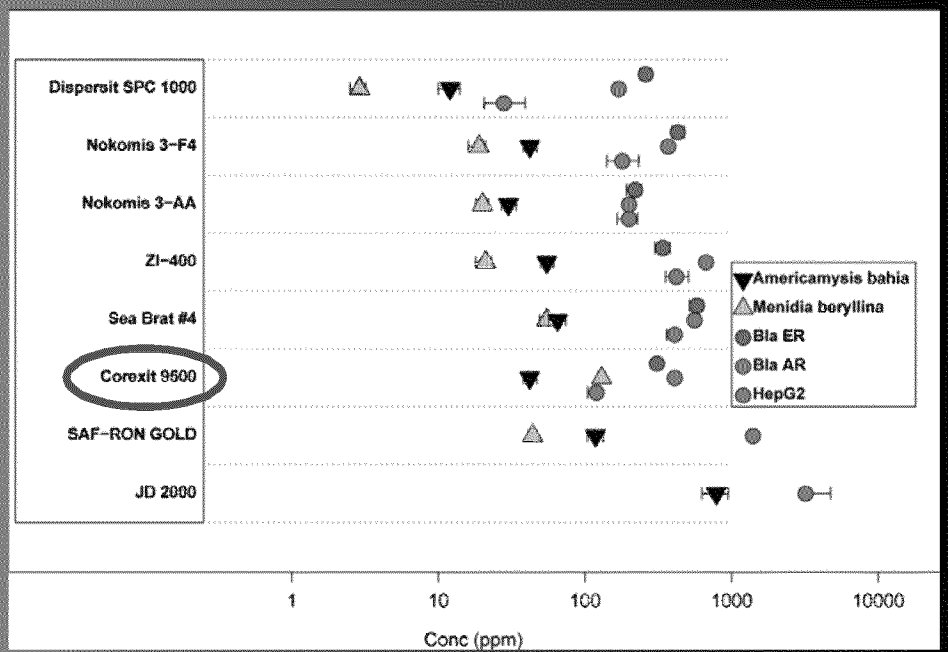
Environ. Sci. Technol. **2010**, *44*, 9379–9385

Analysis of Eight Oil Spill Dispersants Using Rapid, In Vitro Tests for Endocrine and Other Biological Activity

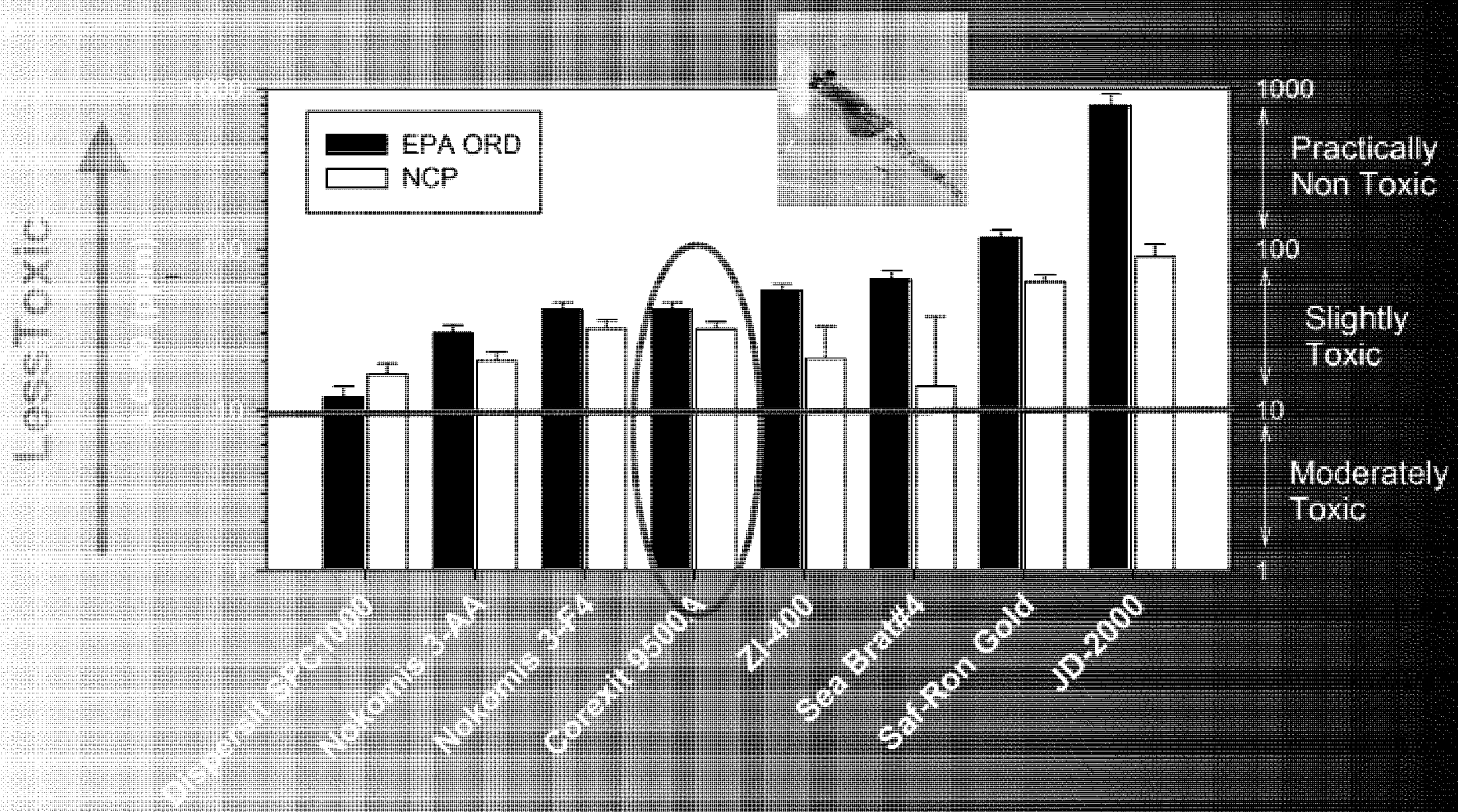
RICHARD S. JUDSON,*,† MATTHEW T. MARTIN,† DAVID M. REIF,† KEITH A. HOUCK,† THOMAS B. KNUDSEN,† DANIEL M. ROTROFF,† MENGHANG XIA,† SRILATHA SAKAMURU,† RUILI HUANG,† PAUL SHINN,† CHRISTOPHER P. AUSTIN,† ROBERT J. KAVLOCK,† AND DAVID J. DIX†

Energy Services, L.P., Sugar Land, TX). In excess of 1.5 M gallons of dispersant have been released into the Gulf as of June 26, 2010. Oil spill dispersants are complex mixtures of two basic components (*1*). The first component is composed of one or more surfactants that can emulsify oil. The second component is a hydrocarbon-based solvent mixture that helps break up large clumps of high molecular weight, more viscous oil. There is limited information on the potential of dispersants to cause acute or long-term toxicity in aquatic species or humans.

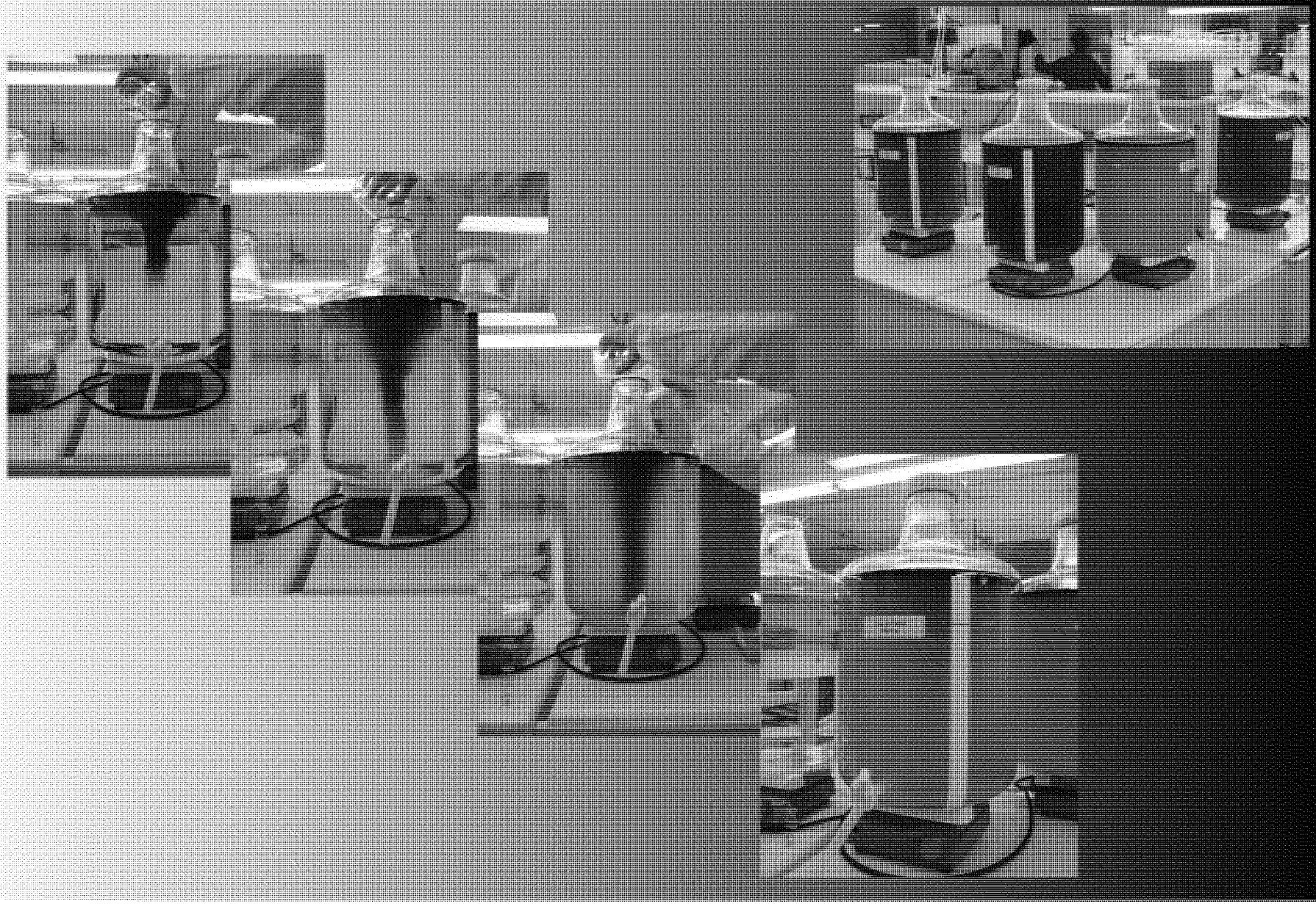
EPA's Office of Research and Development was asked to evaluate the potential toxicity of eight oil spill dispersants, including Corexit 9500. Because of the need for rapid turnaround, it was decided to employ a series of in vitro, cell-based assays. One mode of toxicity that is of concern for dispersants is endocrine disruption (*2*), due to of the fact that nonylphenol ethoxylates (NPEs) are used in some of the dispersants as part of the surfactant component. NPEs can



Comparison of EPA DWH and NCP Dispersant-only test results

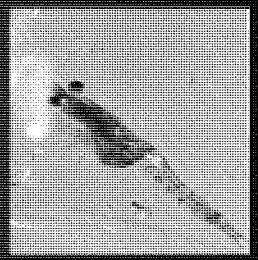


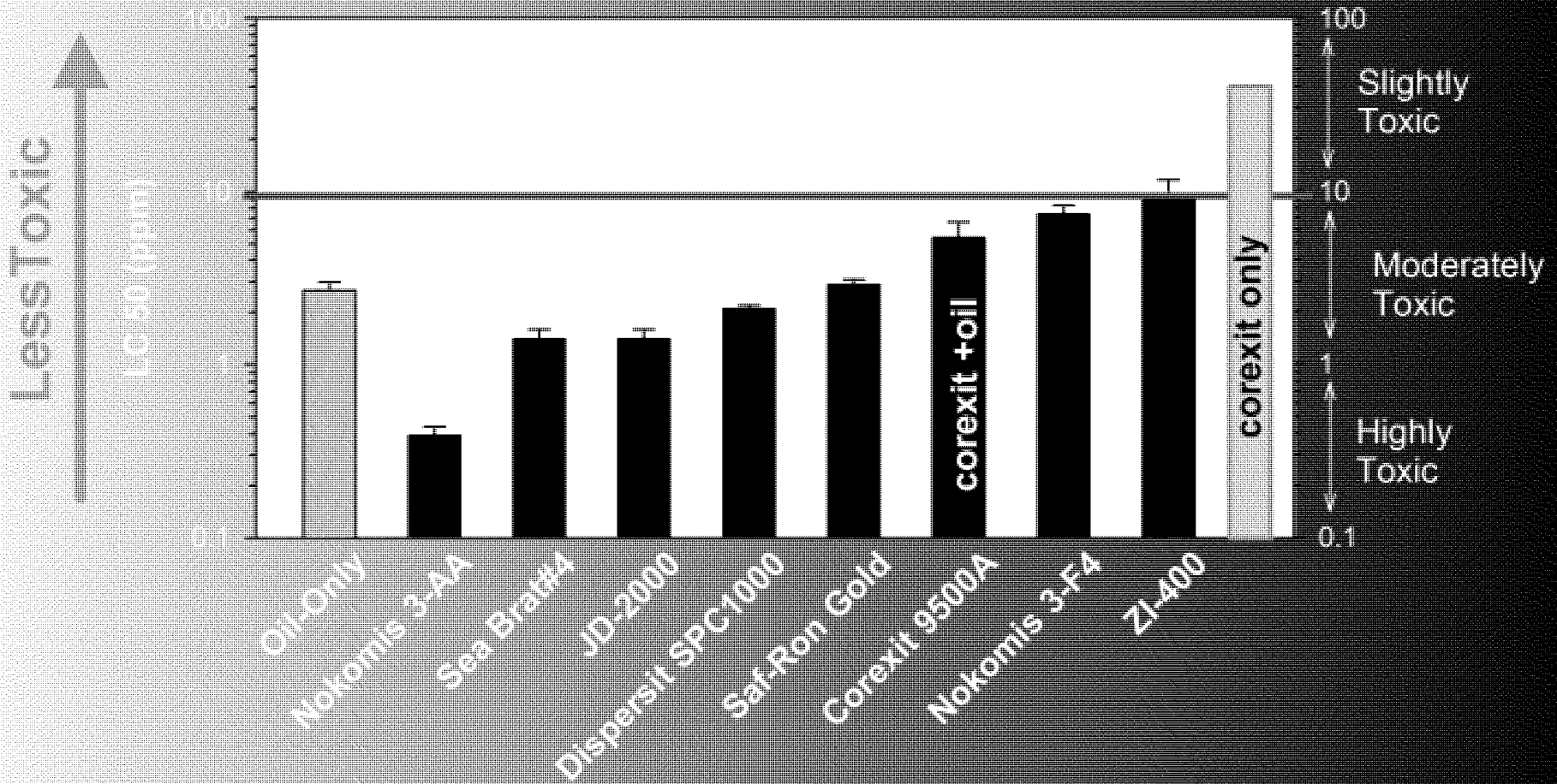
Preparing Dispersant + Oil Mixtures



Dispersant + oil Testing

- similar toxicity as oil alone
- dispersant-only less toxic





Conclusions from EPA DWH Testing

- max efficacy in lab ~80% dispersion
- in vitro toxicity in mammalian cell lines toxicity ≥ 10ppm
- acute ecotox consistent with NCP dispersant testing
- dispersants less toxic than dispersant + oil mixtures
- Corexit 9500A: moderate toxicity; reasonable efficacy

New EPA Testing Program

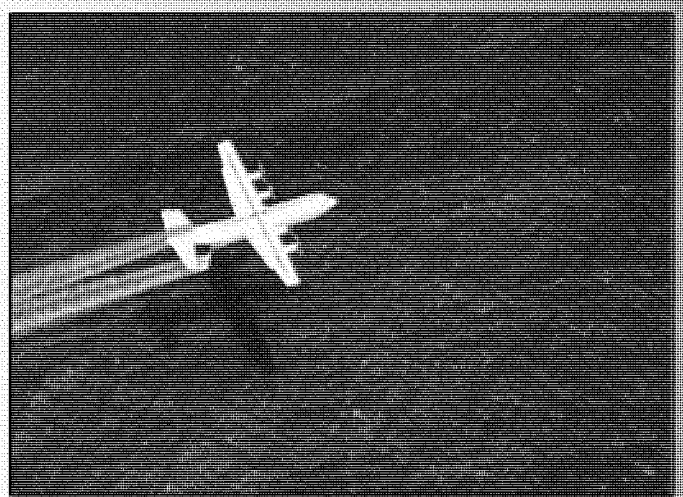
- **dilbits (diluted bitumens; Keystone, other transport)**
  - develop baseline tox data fresh and weathered dilbits
  - marine, freshwater species; acute and sublethal testing
- **crude oils (support for Subpart J proposed rule)**
  - develop baseline data for new EPA reference oils (TBD)
  - evaluate selected dispersants to determine impact on listing
  - expand testing beyond 2 standard test species
  - evaluate and refine proposed toxicity test guidelines

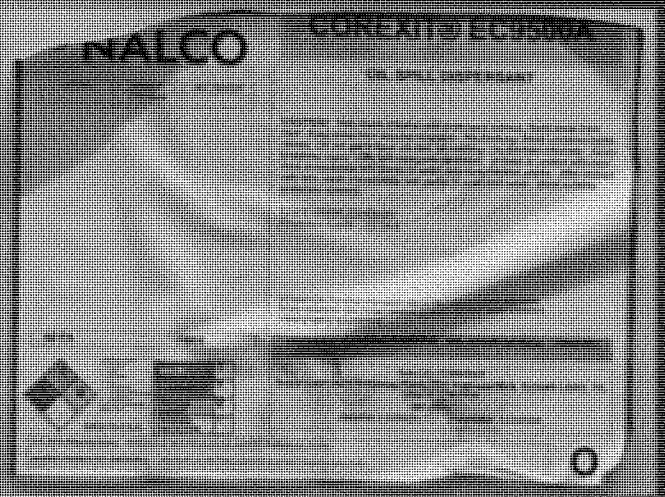
Implications for Spill Response

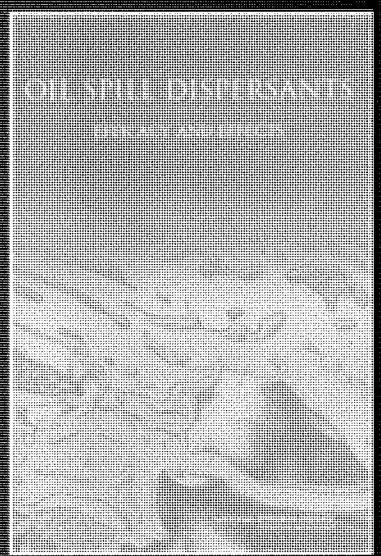
- Effectiveness depends on:
  - accuracy of application
  - oil type and weathering (less effective on heavy, weathered oils)
  - how well mixed with oil (sufficient wave energy)
- Reduce risks to shorelines and surface species (birds, turtles, dolphin)
- Increased risk to subsurface species (top 30 feet of water column)
  - impacts to sub-surface resources less obvious
- Standard toxicity testing only evaluates short term exposures
  - sublethal and long term effects possible; research ongoing

Determining Dispersant Use

- Will mechanical response be sufficient?
- Is the spilled oil known to be dispersible?
- Are sufficient chemical response assets available?
- Are environmental conditions conducive to successful application and dispersion?
- Will application reduce water surface and shoreline impacts without significantly increasing aquatic life impacts?







QUESTIONS?

Mace Barron
Barron.mace@EPA.gov
Gulf Ecology Division, U.S. EPA
1 Sabine Island Drive, Gulf Breeze FL 32561
(850) 934 9223

To: Sprenger, Mark[Sprenger.Mark@epa.gov]; Robyn Conmy[Conmy.Robyn@epa.gov]; Mace Barron[Barron.Mace@epa.gov]
Cc: Principe, Vanessa[principe.vanessa@epa.gov]; Field, Chris[Field.Chris@epa.gov]; Craig Matthiessen[Matthiessen.Craig@epa.gov]; Marc Greenberg[Greenberg.Marc@epa.gov]; Roberta Runge[Runge.Roberta@epa.gov]; Combes, Marcia[Combes.Marcia@epa.gov]
From: Wilson, Gregory
Sent: Wed 1/21/2015 4:32:28 PM
Subject: FW: State-of-Science for dispersant use in Arctic waters OC
2015.01.15_Degradation and Fate Finalpck.docx
2015.01.14_Efficiency and Effectiveness Final pck.docx
2015.01.15_Physical Transport and Chemical Behavior Finalpck.docx
2015.01.15_Public Health and Food Security_pck.docx
2015.01.15_Toxicity and Sublethal Impacts Finalpck.docx

All –

Attached are summary documents from each session of the State-of-Science for dispersant use in Arctic waters workshop that was held in Seattle. You will get the document for your individual session through Nancy/Kathy (CRRC), but we wanted to make sure you had copies of the initial drafts from all the sessions that we received as the organizing committee in case you had questions. While you will be requested feedback from the session(s) you participated in, you may want to contact your fellow EPA participant(s) if you have questions or comments on the other sessions so that they may consider that feedback.

Once again, we would like to thank everyone who participated and attended the sessions. We appreciate all your hard work!

Greg

From: Mandsager, Kathy [mailto:kathy.mandsager@unh.edu]
Sent: Thursday, January 15, 2015 9:49 AM
To: 'doug.helton@noaa.gov'; 'gary.shigenaka@noaa.gov'; 'philip_johnson@ios.doi.gov'; Runge, Roberta; 'lholland-bartels@usgs.gov'; 'stacey.l.crecy@uscg.mil'; 'mark.everett@uscg.mil'; 'kristin.ryan@alaska.gov'; 'mark.swanson@pwsrcac.org'; saupe@circac.org; 'lmajors@alaskacleanseas.org'; nancy.kinner@unh.edu; Kinner, Peter
Cc: Wilson, Gregory; Principe, Vanessa
Subject: RE: State-of-Science for dispersant use in Arctic waters OC

And here are the documents for your review for today's call.

From: Mandsager, Kathy
Sent: Wednesday, January 14, 2015 2:30 PM
To: 'doug.helton@noaa.gov'; 'gary.shigenaka@noaa.gov'; 'philip_johnson@ios.doi.gov'; 'runge.roberta@epa.gov'; 'lholland-bartels@usgs.gov'; 'stacey.l.crecy@uscg.mil'; 'mark.everett@uscg.mil'; 'kristin.ryan@alaska.gov'; 'mark.swanson@pwsrcac.org'; 'saupe@circac.org'; 'lmajors@alaskacleanseas.org'; Kinner, Nancy; Kinner, Peter
Cc: 'Wilson, Gregory'; 'Principe, Vanessa'
Subject: RE: State-of-Science for dispersant use in Arctic waters OC

Mark your calendar for our call tomorrow: Thursday 15 January at 3:00 pm EST.

Dial 866.906.9888 pin: 9606919

Documents for your review forthcoming.

From: Mandsager, Kathy
Sent: Tuesday, January 13, 2015 1:35 PM
To: 'doug.helton@noaa.gov'; 'gary.shigenaka@noaa.gov'; 'philip_johnson@ios.doi.gov'; 'runge.roberta@epa.gov'; 'lholland-bartels@usgs.gov'; 'stacey.l.crecy@uscg.mil'; 'mark.everett@uscg.mil'; 'kristin.ryan@alaska.gov'; 'mark.swanson@pwsrcac.org'; 'saupe@circac.org'; 'lmajors@alaskacleanseas.org'; Kinner, Nancy; Kinner, Peter; Mandsager, Kathy
Cc: 'Wilson, Gregory'; 'Principe, Vanessa'
Subject: State-of-Science for dispersant use in Arctic waters OC

Dear Organizing Committee members:

We wish to thank you for all your efforts in making last week's workshop such a great success!

We will have a draft of the outcomes for your review later this week, but in the meantime, I would like to schedule a conference call as follow-up from our meetings last week and to lay out our next steps. Please kindly let me know your availability for these times for a 1-hour conference call, with the understanding that we may not be able to get all of you together.

Thursday 1/15 at 3:00 pm ET

Friday 1/16 at 11:00 am ET

Friday 1/16 at 1:00 pm ET

Kathy Mandsager

Program Coordinator

Coastal Response Research Center

Center for Spills in the Environment

234 Gregg Hall, Colovos Rd

University of New Hampshire

Durham, NH 03824

603.862.1545

To: Mace Barron[Barron.Mace@epa.gov]
Cc: Craig Matthiessen[Matthiessen.Craig@epa.gov]; Principe, Vanessa[principe.vanessa@epa.gov]
From: Wilson, Gregory
Sent: Fri 7/31/2015 5:26:59 PM
Subject: FW: Potential OSRP Requirement for Oil Toxicity Information as it Pertains to Dispersant Monitoring
DTox_final_report_bejarano_022814.pdf

Steve Lehmann response to Caplis email.

From: Steve Lehmann - NOAA Federal [mailto:steve.lehmann@noaa.gov]
Sent: Friday, June 05, 2015 2:23 PM
To: Caplis, John
Cc: Debbie Payton - NOAA Federal; Matthiessen, Craig; Wilson, Gregory; David Moore
Subject: Re: Potential OSRP Requirement for Oil Toxicity Information as it Pertains to Dispersant Monitoring

John,

You are going to be one popular guy with industry. Greg and Craig are high-fiving themselves now because there is now someone other than EPA for industry to hate.

Assumptions:

1. RRTs and ACs can establish requirements for ecotoxicity testing and monitoring as part of their development of authorization of use plans and their subsequent adoption into ACPs and RCPs.

True, but I don't think that gives BSEE the freedom to do it under their OSPR regulations as a condition for pre-authorization. That said, DOI could make their approval conditional on satisfying BSEE regs. at the RRT level.

2. Ecotoxicity monitoring is primarily monitoring for TPH levels and comparing them to ecotoxicity benchmarks for levels of concern.

I am not a toxicologist, but establishing benchmarks and adding to the SSD data is not monitoring. It requires a battery of tests that can be expensive.

3. Ecotoxicity benchmarks are derived from SSDs for a toxicant (or group of similar toxicants).

Again, not a toxicologist, but toxicity data develops the SSD. The establishment of benchmarks or levels of concern are typically done by the stakeholders and not the industry. You might have to be specific as the species you want plan holders to test.

Question: Who would develop the SSDs? Industry or RRTs?

Most RRTs don't have qualified toxicologists on them for the development of SSD. If industry develops them, the RRTs (or government) would still have to check them, I suspect.

4. SSDs would be formulated using LC50 data on various toxicants such as an oil that is being transported or produced or the dispersant product being used. Industry would provide LC50 toxicology data for their oils when available as part of the OSRP requirements.

Question: Who determines what species should be used for the devleopment of SSDs?

See attached paper by Dr. Bejarano of RPI (a real toxicologist). Also this EPA FAQ is helpful. (http://www.epa.gov/caddis/da_advanced_2.html).

5. Authorization of use plans may establish the species types to be used in developing SSDs.

1. Your language focuses on the oil type rather than the dispersant type or the species present near the facility but NOT represented on the SSD. Why? Means a lot more testing.

2. The first sentence begins with a conditional clause, "Where Area Contingency Plans or Regional Contingency Plans have established the use of Total Petroleum Hydrocarbon (TPH)-based ecotoxicity benchmarks as part of the monitoring requirements for the sustained use of dispersants," but never satisfies that clause. Perhaps you meant, "...*you will include* the toxicity data for your oil that is necessary to develop the species sensitivity distributions (SSDs)..."

Just a quick answer, John. I'll give it some more thought.

Steve

Possible OSRP Language for their Facility Information Annex:

" (b) A listing of the types and characteristics of the oil handled, stored, or transported at each offshore facility.

(1) You must provide the following additional information on your oil properties and behaviors:

(2) Oil weathering data

(3) Dispersibility data

(4) Where Area Contingency Plans or Regional Contingency Plans have established the use of Total Petroleum Hydrocarbon (TPH)-based ecotoxicity benchmarks as part of the monitoring requirements for the sustained use of dispersants, **the toxicity data for your oil** that is necessary to develop the species sensitivity distributions (SSDs) identified in the those Area and Regional Contingency Plans. This requirement is limited to offshore facilities or leases physically located in areas where Area Committees or Regional Response Teams have established monitoring requirements in their Regional or Area Contingency Plans that include the use of TPH-based ecotoxicity benchmarks for a sustained use of dispersants that is generally consistent with your planned response to your WCD scenarios.

On Fri, Jun 5, 2015 at 10:51 AM, Caplis, John <john.caplis@bsee.gov> wrote:

Please do not forward or share beyond a very limited number of internal SMEs you deem appropriate to the conversation, as this is pre-decisional and regulatory sensitive info.

Debbie, Craig, Steve, Greg,

We are toying with the idea of requiring plan holders to conduct and submit toxicity testing that would support the development of species sensitivity distributions necessary for the development of ecotoxicity benchmarks, as part of their OSRP requirements (as part of our pending OSRP regulatory update). You all are more knowledgable in this arena than I, so I wanted to get your expert opinions as well as verify that I am understanding how things might work in conjuction with both within the NRT Guidelines for Atypical Use of Dispersants and the evolution of Subpart J. As you will see, I have a few questions below, and am also interested in any thoughts, concerns, and suggested changes you might have, as we consider this possible requirement:

Assumptions:

1. RRTs and ACs can establish requirements for ecotoxicity testing and monitoring as part of their development of authorization of use plans and their subsequent adoption into ACPs and RCPs.

2. Ecotoxicity monitoring is primarily monitoring for TPH levels and comparing them to ecotoxicity benchmarks for levels of concern.

3. Ecotoxicity benchmarks are derived from SSDs for a toxicant (or group of similar toxicants).

Question: Who would develop the SSDs? Industry or RRTs?

4. SSDs would be formulated using LC50 data on various toxicants such as an oil that is

being transported or produced or the dispersant product being used. Industry would provide LC50 toxicology data for their oils when available as part of the OSRP requirements.

Question: Who determines what species should be used for the devleopment of SSDs?

5. Authorization of use plans may establish the species types to be used in developing SSDs.

Possible OSRP Language for their Facility Information Annex:

" (b) A listing of the types and characteristics of the oil handled, stored, or transported at each offshore facility.

(1) You must provide the following additional information on your oil properties and behaviors:

(2) Oil weathering data

(3) Dispersibility data

(4) Where Area Contingency Plans or Regional Contingency Plans have established the use of Total Petroleum Hydrocarbon (TPH)-based ecotoxicity benchmarks as part of the monitoring requirements for the sustained use of dispersants, the toxicity data for your oil that is necessary to develop the species sensitivity distributions (SSDs) identified in the those Area and Regional Contingency Plans. This requirement is limited to offshore facilities or leases physically located in areas where Area Committees or Regional Response Teams have established monitoring requirements in their Regional or Area Contingency Plans that include the use of TPH-based ecotoxicity benchmarks for a sustained use of dispersants that is generally consistent with your planned response to your WCD scenarios.

So what do you all think about the assumptions, or the proposed requirement language? I am appreciative of any feedback you want to offer on anything you see in this email. (Please ignore the underlining, it doesn't have any significance).

John

--

Stephen Lehmann
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DTox: a Worldwide Quantitative Database of the Toxicity of Dispersants and Chemically Dispersed Oil

A Final Report Submitted to

The Coastal Response Research Center

Submitted by

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Coastal Response Research Center

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UNIVERSITY of NEW HAMPSHIRE

NOAA

Abstract

The *Deepwater Horizon* oil spill revived much of the discussions on the use of dispersants as one of the tools considered in offshore oil spill response. Much of this discussion focused on concerns about the toxicity of dispersants and chemically dispersed oil to water column organisms. The ability to rapidly assess the toxicity of dispersants and chemically dispersed oil require unrestricted and rapid access to available toxicity data, a need shared by government, industry, consultants, and academic groups involved in oil spill response. While toxicity data on dispersants and both physically and chemically dispersed oil have been generated since the 1970s, the practical use of this information has been hindered by the lack of a centralized data repository. As a result, the Dispersant and Chemically Dispersed Oil Toxicity Database (DTox) is created to address that shared need of the oil spill community.

The main objectives of this project are to: 1) identify, evaluate, compile, and integrate all available toxicity data on dispersants and chemically dispersed oil, and 2) generate an interactive tool that can assist the oil spill response community in their assessments and management decisions regarding the use of dispersants. The ultimate goal of this effort is the synthesis of information in a meaningful way to improve scientific decision-making as well as to provide rapid access to centralized toxicity data. DTox includes information on over 35 data attributes (e.g., species scientific name, life stage tested, dispersant name, exposure type, oil weathering stage, exposure duration, etc.), compiled through a careful review of existing data extracted from the peer-review and gray literature. Data considered for inclusion in DTox are rigorously evaluated following a strict set of rules aimed at selecting the best available and suitable data that are further evaluated through detailed Quality Assurance/Quality Control (QA/QC) procedures, which included a review of at least 15% of all records in the database. Each data source in DTox is further evaluated and given an applicability score based on its relevance to oil spills, and not on its scientific merits. Key criteria in the determination of source applicability include exposure type, reported effects concentrations, and reported analytical chemistry. Data from 400 papers (peer-review and gray literature) were evaluated for their potential inclusion into the database, and data extracted from +160 of these sources. Information in DTox is integrated into a user-friendly tool that allows for on-the-fly data searches and data plotting in the form of Species Sensitivity Distributions, based on the specific needs of an end-user. This tool can assist with the development of risk estimates related to oil spills by allowing the selection of data that most closely match the needs of an end-user.

The effectiveness, usefulness, and transferability of DTox to oil spill response are evaluated through oil spill drills, dispersant-related workshops, and dispersant-related assessment. These exercises showed that, despite existing data limitations, DTox provides information that can be used to inform tradeoff decisions based on the current state of knowledge. Data in DTox have the potential to contribute to a better understanding of the biological effects of dispersants and oil in the aquatic environment, and can provided useful information to both environmental assessments and decision making efforts. Future efforts will focus on maintaining and updating DTox and expanding its use capabilities in oil spill response community.

Keywords: Dispersant, DTox, Oil spill response, Chemically dispersed oil, Species Sensitivity Distributions.

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This research was made possible by a grant from NOAA and the University of New Hampshire's Coastal Response Research Center (Contract No. 13-034) to Research Planning, Inc. None of these results have been reviewed by CRRC and no endorsement should be inferred.

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1.0 Introduction

During the *Deepwater Horizon* oil spill an unprecedented volume of dispersants was used as a response tool to accelerate the natural biodegradation of oil and help minimize the impacts of oil on sensitive nearshore and shoreline habitats and resources (Lubchenco et al., 2012). This exceptional use of dispersants raised concerns among the public and many scientists about the toxicity of dispersant and chemically dispersed oil to water column organisms. While aquatic toxicity testing of dispersants and chemically dispersed oil has been conducted under laboratory and field conditions for at least four decades (e.g., NRC, 1989, 2005, and more recent studies) the practical use of this information, particularly to communicate risks and to address misconceptions about the use of dispersants, was limited by the lack of a centralized data repository (a data gap identified by CRRC et al., 2012). While aquatic toxicity databases contain toxicity data on dispersants and petroleum products (e.g., CAFÉ-NOAA/ERD, AQUIRE-USEPA), a database solely dedicated to consolidating in a meaningful way decades of existing toxicity data on dispersants and both physically and chemically dispersed oil was nonexistent at the time. As a result, Dispersant and Chemically Dispersed Oil Toxicity Database (DTox) is developed to address the shared need of the national and international oil spill community for access to toxicity data. The main objectives of this project are to review and integrate all available toxicity data on dispersants and chemically dispersed oil into an interactive tool that can assist the oil spill response community in their management decisions regarding the use of dispersants.

While it is clear that additional research is needed to improve our understanding of the biological, toxicological, and ecological effects of dispersants and chemically dispersed oil to a wide range of aquatic species (CRRC et al., 2012), and despite data limitations, decades of research in this field can provide valuable information to the oil spill response community and practitioners. As evident during the *Deepwater Horizon* oil spill, the ability to assess the toxicity of chemically dispersed oils is a goal shared by oil spill responders, where a common requirement is the unrestricted and rapid access to the available toxicity data, compiled following a detailed Quality Assurance/Quality Control plan.

2.0 Objectives

The main objectives of this project are to identify, evaluate, compile, and integrate all available toxicity data on dispersants and both physically and chemically dispersed oil generated under laboratory and field conditions, and to generate an interactive tool that can assist the oil spill response community in management decisions regarding the use of dispersants. The ultimate goal of this effort is the synthesis of information in a meaningful way to improve scientific decision-making as well as to provide rapid access to centralized toxicity data. The specific objectives of this project are to:

1. Identify documents and peer-review and gray literature (e.g., field, laboratory, mesocosm, accidental oil spills) reporting toxicity data (acute and chronic) of dispersants and chemically dispersed oil;
2. Rigorously evaluate each data source for quality and potential for inclusion in the DTox database;

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3. Compile all quantitative information including all relevant fields (e.g., species, exposure conditions, oil type and weathering, etc.);
4. Integrate the above information into a tool that can be used by the end-user to guide management decisions regarding the use of dispersants; and
5. Test the suitability of the compiled quantitative data for use in spill response at two pilot study areas.

3.0 Methods

The identification of peer-review and gray literature documenting the toxicity of dispersants and physically and chemically dispersed oil was done via a combination of online searches, visits to web sites of government agencies, industry, and research institutions, and direct contact with leading researchers in the field. Hard copies or electronic versions of each data source were obtained and cataloged in EndNote® prior to their review. Each data source was rigorously evaluated for their potential for inclusion in DTox following the Quality Assurance/Quality Control (QA/QC) plan developed for this project (see Appendix A for details). Examples of data criteria are shown in Table 1.

Table 1. Examples of some of the criteria used to evaluate each data source for their potential inclusion in DTox. Studies not satisfying these requirements are not included.

Criteria	Requirement/Inclusions	Limitations/Exclusions
Dispersant	Documented commercial name	Not documented
Oil	Documented fresh/weathered oil name or source	Not documented
Species	Aquatic invertebrates, vertebrates, marine bacteria	Mammals, reptiles
	Documented taxonomic information verifiable against standard taxonomic sources	Species or common name not documented
Effect/ Response	Biological effect on live, whole organisms	Dead organisms; in-vitro studies
	Adverse acute or chronic effects	Beneficial, nutritional effects
Exposure conditions	Water only exposures	Sediment, other exposures
	Acceptable control survival (at least 70%), or acceptable control endpoints	Poor control survival or unacceptable control endpoints
	Documented experimental conditions (e.g., flow through, static)	Not documented
	Documented exposure durations conditions associated with biological effects (e.g., flow through, static)	Unverifiable duration, not reported
	Documented effects concentrations	Not documented

Data were entered into a carefully designed database template in a systematic and consistent fashion. Examples of database elements (see Appendix A for details) included: 1) species attributes: taxonomic group, common name, scientific name, life stage, species distribution; 2) experimental conditions and settings: study type, water type, oil name and weathering condition, dispersant name, dispersant-to-oil ratio, exposure type, exposure duration; 3) endpoints: acute,

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subacute, effects concentration, effects concentration units, analyte name, analytical methods; and 4) data source: author name, publication year, article title. Whenever possible, entries were standardized facilitating further sorting and treatment of the existing data. An additional field was created to score the applicability of each data source (e.g., High, Moderate, Low) to spill response. Source applicability is based on the relevance of each data source to oil spill response, and not on the overall scientific merit of individual sources (see Appendix A for details). Data entered into the database template went through several QA/QC evaluations to ensure that each record accurately represented the information and data of the original data source (see Appendix A for details). Critical steps of the QA/QC process included the review of currently accepted scientific species names, standardization of column content and applicability criteria, and identification of duplicate data (e.g., several papers by the same author(s) reported in several report/manuscripts). Identifying duplicate data is an important step because it affects the values per species plotted on Species Sensitivity Distributions (SSD) (see below). Consequently, duplicate data are not removed from the database, but are not used in SSD calculations. The revised dataset is then migrated into a database program (FileMaker® Pro 12) with expanded capabilities, allowing the development of an interactive, searchable, and user-friendly tool that allows for visual exploration and examination of data (suggested citation Bejarano and Dahlin, 2013).

4.0 Results

4.1 Compiled Toxicity Data

Over 400 papers from peer review and gray literature were initially screened for their potential inclusion into the database. The complete list of citations of all papers reviewed as part of this project was compiled into an EndNote® library. This library is available to the larger oil spill community through the PI and/or CRRC. Although many of the data sources originally reviewed contained important information, many are not included in DTox because these were not the original data source and, therefore, the quality of these papers could not be judged based on the information provided (see Appendix A for details). Of these initially screened papers, data were extracted from +160 sources amounting to +3500 rows of records. A graphic representation of the type of data currently in DTox is shown in Figure 1. To date, this database contains toxicity data for +100 oils, +120 dispersants, and +190 unique aquatic species, amounting to +3,500 toxicity records. The large majority of records are for species with subtropical distributions (+1,200 records), followed by temperate species (+900 records). Cold-water species and tropical species are the most underrepresented group by geography (+800 records combined). Most currently available toxicological records are for species (and life stages) found in the water column (+2,400 records), while a considerably lower number of records are available for species from the other two general habitats (benthos and epibenthos) (+1,500 records combined). When looking at the number of records by taxonomic group, most records are for fish (+1,500 records) followed by crustaceans (+1,400 records), while other groups, especially corals are underrepresented in the database. At least one third of all records are for 13 U.S. standard test species (+1,300 records), with data for mysid shrimp (*Americamysis bahia*) and inland silverside (*Menidia beryllina*) comprising nearly 50% of all standard test species records.

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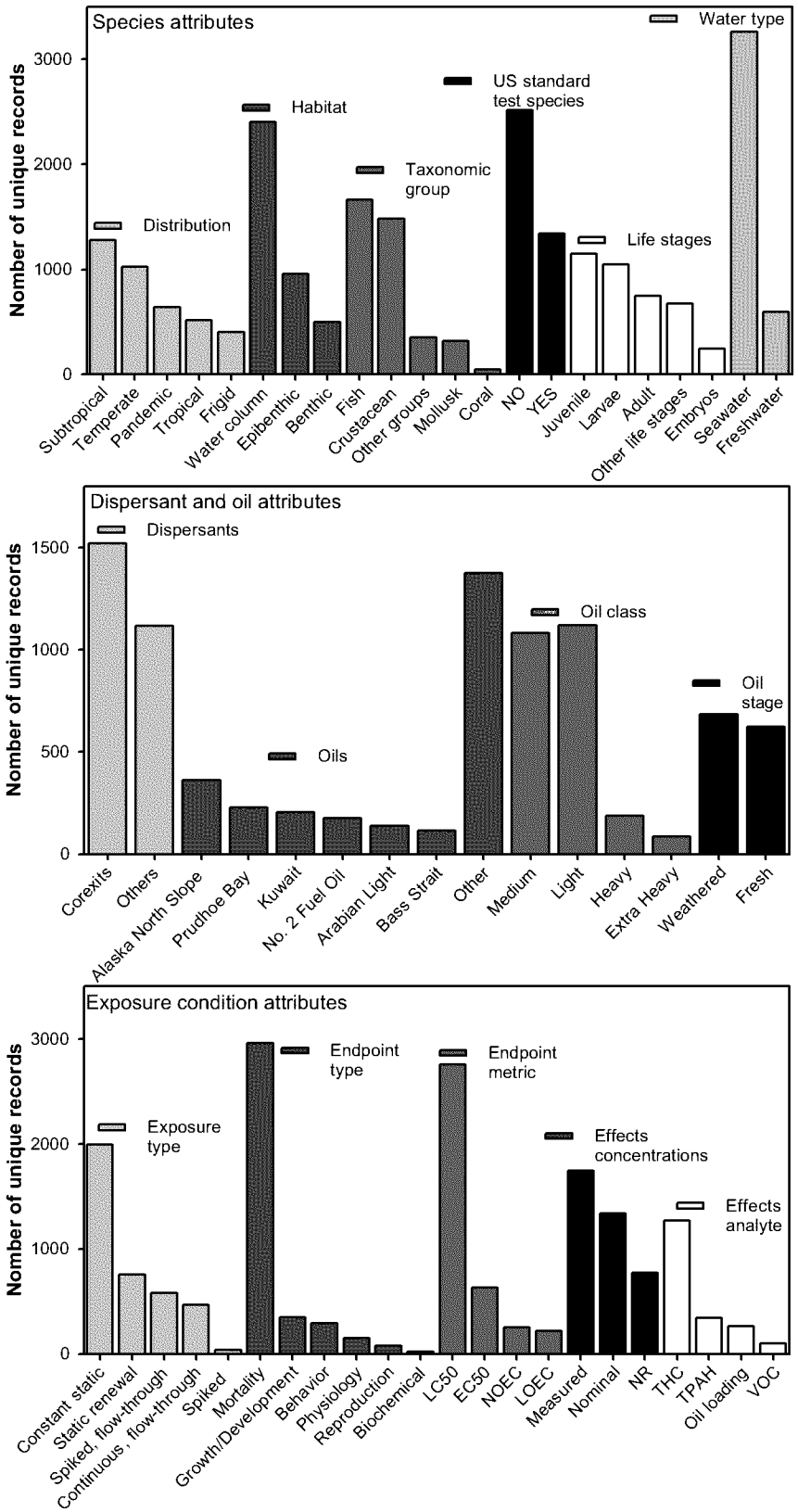

Figure 1. Breakdown of final QA/QC data and information currently in DTox by species attributes (top); oil/dispersant attributes (middle); and exposure conditions (bottom).

Based on the currently available information, it is clear that there was a surge of toxicity studies on dispersants and oil in the mid 1970s, declining drastically through the 1980s. Since the late 1980s, there have been a variable number of studies, as reflected in the number of records in DTox. Nearly one fifth of all records (+700 records) has been generated since 2010, likely driven by the *Deepwater Horizon* oil spill[1]. The most studied dispersants are the Corexits (+1,500 records; specifically Corexit 9500, Corexit 9527 and Corexit 7664), while the most studied oils are Alaska North Slope, Prudhoe Bay, and Kuwait oil (+700 records combined). The large majority of oil records (+2,000) are for light and medium oils (based on API gravity), while heavy and extra heavy oils are underrepresented in the database (+200 records combined). A large percentage of records (70%) are derived from 48- and 96-hour exposures (+2,500 records), and via static exposures (+2,400 records). Of the 171 peer-review and gray literature papers included in DTox, 37, 52, 72 were given High, Moderate and Low Applicability scores, respectively. Ten data sources were rejected.

It is important to note that there are additional data sources not currently in DTox (e.g., data currently under peer review, data unavailable because of confidentially agreements, data under litigation, older reports requiring company approval for release, etc.), and it is hoped that these data would be included in future updates of the existing database. Specifically, NOAA/BP data from the *Deepwater Horizon* oil spill are not currently available for inclusion into the database, but requests have been made to ensure that upon their release from embargo, these data will be entered into DTox following the same procedures and QA/QC plan developed during this project.

4.2 DTox-Version 1

The ultimate goal of this effort is the synthesis of information in a meaningful way to improve scientific decision-making as well as to provide rapid access to centralized toxicity data. As a result, a user-friendly tool was created to facilitate data querying. This tool is designed to allow the end-user to navigate through a series of screens where data selections can be made, narrowing the type and amount of information used in data plotting. Prior to the distribution of the first version of DTox to a selected number of end-users, a beta version of DTox was extensively tested both internally and externally by a number of individuals (testers). This step was critical to ensure that the tool met the requirements expected of an interactive tool. During the testing window, recommendations were made to improve the appearance and functionality of the tool, and a series of glitches and technical issues were identified and addressed. These early evaluations allowed the project team to address any outstanding issues and improve the presentation of the tool prior to its public release. The end-result is the production of a DTox-Version 1 tool (suggested citation Bejarano and Dahlin, 2013). Examples of the navigation windows of the first version of DTox are shown in Figure 2. Note that the first window includes a clear disclaimer, and a request for reporting of errors and inconsistencies. A window is also included to clearly acknowledge the funding source. More detailed information regarding DTox-Version 1 is provided in Appendix B, a document that is also included as a pdf within the interactive tool.

[1] Data generated through to support NRDA from the *Deepwater Horizon* oil spill are not currently included in the database.

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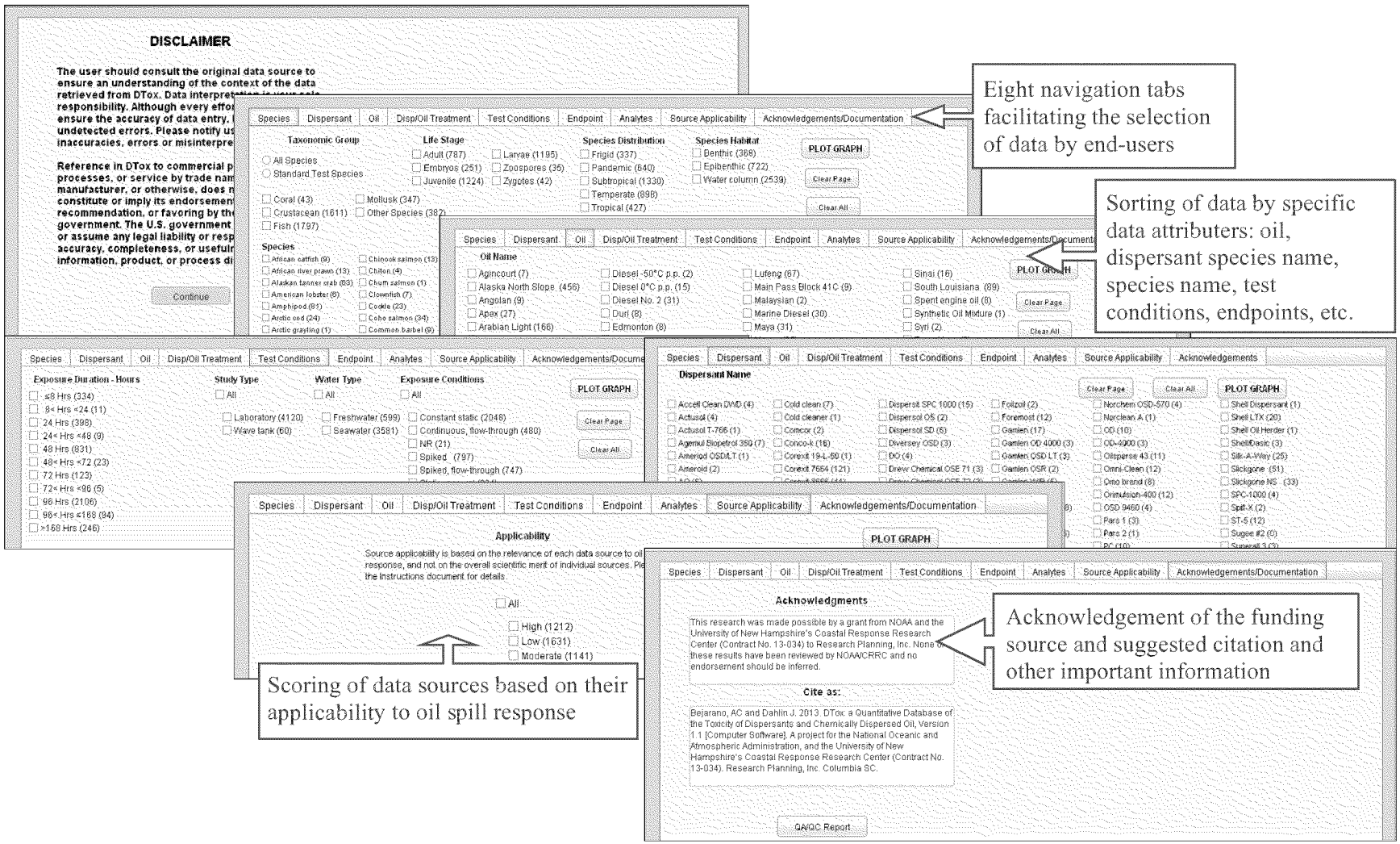

Figure 2. Examples of navigation tabs where the end-user can query the available data. A total of nine navigation tabs are currently available in DTox (Version 1).

Following data selection from the navigation windows, the remaining data are plotted in separate windows in the form of Species Sensitivity Distributions (SSDs) (Figure 3). SSDs are probabilistic models that describe the relative sensitivity of species to a particular compound or compound mixture (Posthuma et al., 2002), where species are ranked, based on their relative sensitivity, from the least to the most sensitive. As a result, each dot on a SSD represents a unique species, specifically the geometric mean of reported toxicity values. In DTox, SSDs are generated for datasets with a minimum of 5 species by fitting the empirical toxicity data to a logistic function defined by $F(x) = \frac{1}{1 + e^{-(x-\mu)/\sigma}}$, $x \in R$, with parameters μ(location) and σ (scale). SSDs are advantageous in that these allow for comparison of the sensitivity of different species to the same type of exposure (e.g., dispersant only, oil only, chemically dispersed oil), and can be used to derive benchmarks or hazard concentrations (HC) (Posthuma et al., 2002). Some of the most commonly used HCs are the HC1 and HC5 equivalent to the concentrations at which 1% and 5%, respectively, of the species in the SSD may not be protected. When enough data are available for curve fitting, the SSDs also display the estimated HC1 and HC5 values from the logistic curve.

The current version of DTox (Version 1) allows for up to two SSDs per display window (Dispersant Only, Dispersant and Oil, Oil Only) based on the following data fields: exposure duration, dispersant name, or oil name. When only one curve is plotted, common names are displayed to facilitate data interpretation. For better visualization and interpretation of data, the queried data are displayed based on color coding the selections (e.g., by taxonomic group; by species distribution). All SSDs are plotted over a colored background representing a common scale used to rank the relative toxicity of contaminants (http://www.epa.gov/oppefed1/ecorisk_ders/toera_analysis_eco.htm#Ecotox) (see Figure 3 for details). Other features of DTox include a selection criteria tab that displays the selections made through the navigation tabs, and a report tab displaying the information used to plot the SSDs with the option of exporting both SSDs and summary data to a pdf file. DTox also contains the complete QA/QC plan used in the development of the tool (Appendix A), and a "How To" document (Appendix B), guiding end-users how to navigate and understand navigation tabs and query options, and providing examples on how to use outputs generated from this tool. This document also highlights some of the existing limitation with the current version of DTox. DTox also contains the EndNote® library with the complete list of citations of all papers reviewed as part of this project.

Throughout the development of DTox, care was taken to address individuals with disabilities (Section 508 29 U.S.C. '749d) particularly by selecting color palettes (whenever possible) designed to be readable by individuals with color blindness. A stand-alone executable file of DTox (Versions 1), which can be run in desktop and laptop computers, was made available to a selected number of end-users. As mentioned previously, prior to the distribution of DTox (Version 1), the tool was extensively tested both internally and externally by a number of testers. While these early evaluations allowed the project team to address issues prior to its public release, it is acknowledged that the organization of copious amounts of toxicity data into a practical, versatile, and logical system was challenging. However, the tool may still contain issues not currently identified. During training sessions with end-users (see Section 7.1) the PI encouraged participants to report any issues with the tool so that these can be addressed in future

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iterations of DTox. To date, comments have been provided which are summarized in Table 2. Development of additional access forms (e.g., html) may be developed in consultation with NOAA, as this agency may be in charge of the long-term maintenance and future updates of this database.

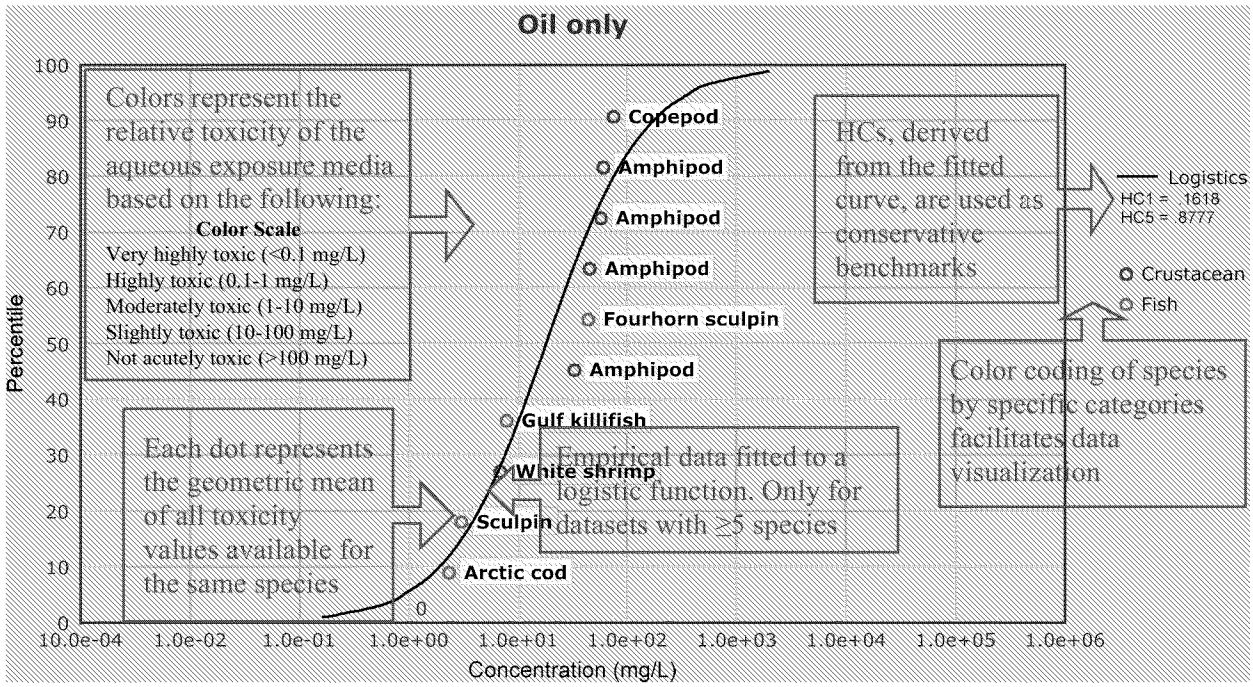

Figure 3. Example of a SSD generated following data queries, where dots represent the empirical data. Hazard Concentrations, HC1 and HC5, represent the benchmark concentrations assumed to be protective of 99% and 95%, respectively, of the species in the SSD.

Table 2. Strengths and limitation of DTox (Version 1) based on feedback provided by end-users.

Strengths
Easy to use (e.g., check boxes, tabs) and intuitive design
Clear display of data in separate tabs according to attributes
Total count of records (in parentheses) are informative
Helpful "Clear Page" and "Clear All" button on each tab
Warning appears when there are not enough data
Single and double plots are informative and well designed
The summary query tab is helpful, particularly when many data selections are made
Both plots and raw data used in plots are easily exported
Well documented tool (complete QA/QC and Instructions documents)
Limitations
Too many selection options
Applicability and life stage are not a shading options
Only common names are displayed. Scientific names should be an option
Names do not appear in double plots
Not enough information displayed on graph output section
Goodness of fit tests are not available (as pointed out by the authors)

4.2.1 DTox-Query Demonstration

In this section a series of queries are performed to demonstrate the usability of DTox (additional queries are presented in Section 4.3).

- Query 1a: Dispersant – Corexit 9500 and Corexit EC9500A; Oil – Prudhoe Bay and Alaska North Slope; Exposure conditions – Constant static, Flow through, Static renewal; Exposure duration – 96-hours; Endpoint metric– LC50, EC50; Concentration – Measured; Analyte – All options containing Total Hydrocarbon Content (THC); Applicability – Moderate, High.
- Query 1b: Identical as Query 1a, but without dispersant selection.
- Query 1c: Identical as Query 1a, but changing Exposure conditions to – Spiked, Spiked-flow-through.

As shown in Figure 4 (Top), the concentration assumed to be protective of 95% of the species in the SSD (HC5) is 0.1 milligrams of total hydrocarbons per liter (mg THC/L) in aqueous exposures to Prudhoe Bay and Alaska North Slope oils that were chemically dispersed with Corexit 9500 and Corexit EC9500A. By comparison, aqueous exposures to the same physically dispersed oils (without dispersants) (Figure 4, Middle) produce an HC5 of 0.3 mg THC/L. While the estimated HC5 values from aqueous exposures to chemically dispersed oil are smaller than those from physically dispersed oil, these two curves are likely not different from each other. These results are consistent with previous conclusions (NRC, 1989, 2005) indicating that there is no strong scientific evidence that the toxicity of chemically dispersed oil is substantially greater than that of physically dispersed oil. Note that Figure 4 (Middle) displays several amphipod species. A tab within DTox (not shown) allows the end-user to determine which amphipod species (scientific name) are included. In this case, *Anonyx nugax*, *Boeckosimus edwardsi*, *Gammarus setosus* and *Onisimus littoralis*.

Data in DTox are also queried to compare the impact of exposure conditions (static-Query1a vs. spiked-Query1b) on toxicity values. As shown in Figure 4 (Bottom), the concentration assumed to be protective of 95% of the species in the SSD (HC5) is 1.66 mg THC/L for spiked exposures, which is an order of magnitude larger (less toxic) than the HC5 value from constant exposures (0.1 mg THC/L). As a result, assessments based on toxicity data from tests performed under constant static exposures may overestimate toxicity, when compared to assessments based on spiked exposures. The latter type of laboratory settings represents more realistic field environmental exposures because these address the dilution that occurs in open waters by reproducing under laboratory conditions rapid changes in concentrations in the water column (Aurand and Coelho, 2005; Clark et al., 2001; George-Ares et al., 1999; NRC, 1989, 2005; Singer et al., 1995).

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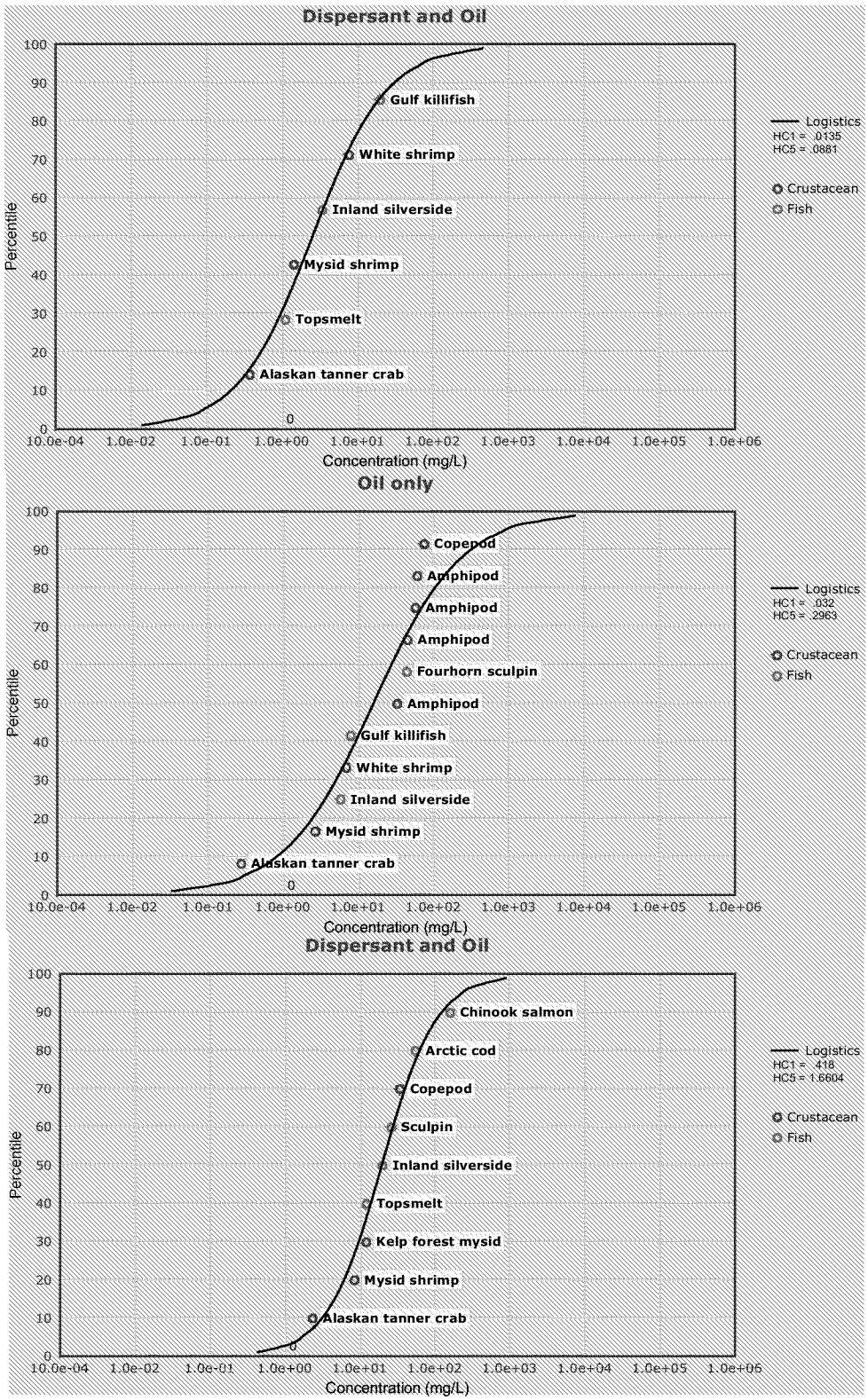

Figure 4. Example of a SSD generated following data queries in DTox. Dots represent the available empirical data. Hazard concentrations, HC1 and HC5, represent the benchmark concentrations assumed to be protective of 99% and 95%, respectively, of the species in the SSD. Top: Query 1a; Middle Query 1b; Bottom: Query 1c. See text for details.

4.3 DTox Applicability to Oil Spill Response and Planning

A database is only useful for storing information if people can correctly and efficiently query, update, and manipulate existing data to inform decisions or to perform assessments. Consequently, critical steps in assessing the effectiveness and usefulness of DTox dealt with its transferability to drills, or real oil spill situations, as well as its ability to provide information that can help inform decisions based on the current state of knowledge. To assess the applicability and transferability of this tool in spill response, two scenarios with different biological and oceanographic conditions are used to test the usefulness of DTox. The location and oil spill volume associated with each of these scenarios was provided by NOAA/ERD, and were based on either planned or past oil spill drills. Testing the applicability and transferability of DTox consists of performing data queries and selecting the appropriate receptor species with associated toxicological data, or user-specified query criteria, from which levels of concern for representative groups of species in these two areas are derived.

Steps involved in assessing the suitability of this database include:

1. Describing a spill scenario, including the location of the spill;
2. Determining the species/groups of species at risk, or species of concern;
3. Selecting the appropriate environmental and search criteria;
4. Conducting data query/queries considering Steps 1-3;
5. Deriving potential levels of concern or risk estimates; and
6. Describing data gaps and sources of uncertainty.

Note: The drills below are for demonstration purposes only and should not be taken out of context. Results and conclusions should not be used beyond the scope of this exercise, which is intended to demonstrate the applicability of DTox in oil spill response and planning.

4.3.1 Drill 1: Bay of Fundy, Maine

Spill scenario (Drill). "At 1200 ADT on Tuesday, June 18, 2013, the tank vessel *M/T NERITINA*, with a full cargo of 1,092,000 barrels (bbl) of Kuwait crude oil is transiting inbound in the Bay of Fundy collided with a cargo vessel. This collision resulted in spill of 35,000 bbl (~4,775 tonnes/1.47 million US gallons) of crude from the *M/T NERITINA*, with a potential secondary release of 50,000 bbl." This scenario is identical to the Canadian/U.S. Joint Response Team full scale exercise for the Atlantic Region (CANUSLANT) (June 17-20, 2013).

Resources at Risk. The islands of coastal Maine support a high diversity and abundance of marine life including birds and marine mammals. Nearshore areas also support productive commercial fisheries for fish and invertebrate species. Because of the ecological importance of nearshore waters to numerous marine species, the use of dispersants is not taken lightly as there are several federally threatened and endangered species (protected under the Endangered Species Act), as well as species of special concern, and species of local significance. A summary of these biological resources of concern is summarized in Table 3.

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Table 3. Biological resources at risk from a release of oil from the *M/T NERITINA*, with focus on nearshore/offshore waters. U.S. Status: FT = Federal threatened; FE = Federal endangered; ST = State threatened; SE = State endangered, SC= State species of special concern. Canada Status: CA-FE = federal endangered; CA-FSC: federal species of special concern.

Species Group	Species Subgroup (Status)	Seasonal Presence	Comments
Birds	Arctic terns (ST)	Nests May-Jun	
	Atlantic puffin (ST)	Nests Apr-Aug	
	Double-crested cormorant	Nests Apr-Jul	
	Harlequin ducks (ST)	Wintering Oct-Mar	
	Leach's storm petrel (SC)		
	Least tern (FE, SE)	Nests May-Aug	
	Piping plover (FT; CA-FT; SE)	Nests May-Aug	
	Razorbill (ST)	Mar-Sep; nests May-Jun	
	Red knot	Migration Jun-Jul	
	Roseate tern	Nests May-Aug	
Marine mammals	Atlantic white-sided dolphin	Calve Jun-Jul	
	Fin whale (FE; CA-FSC)	Peak abundance Apr-Oct	Most frequently found in waters over the continental shelf
	Gray seals	Pup Dec-Feb	
	Harbor porpoise	Calve May-Jun	Found throughout the Bay of Fundy
	Harbor seals	Pup May-Jun	
	Harp seals	Jan-May	
	Humpback whale (FE; CA-FSC)	Moderate abundance Summer	Most frequently found in waters over the continental shelf
	Minke whale		
	North Atlantic right whale (FE, CA-FE)	Peak abundance May-Sep	Found in shallow nearshore waters
	Sei whale (FE, CA-FE)	Peak abundance May-Sep	Most frequently found in waters over the continental shelf
Fish	American plaice		
	Atlantic cod		
	Atlantic halibut		
	Atlantic herring		Offshore spawning areas
	Atlantic salmon (FE; CA-FE)	Apr-Nov	Coastal/inland Maine critical habitat for this species under ESA. Present in the outer Bay of Fundy
	Bluefin tuna	Migration July	
	Halibut		
	Winter and Witch flounder		
Invertebrates	American lobster	Inshore migration Summer	Species of local economic importance
	Northern shrimp	Spawn Nov-May	
	Rock crabs		
	Sea scallop		

One of the main resources of concern in the area is the American lobster (*Homarus americanus*), which is an iconic commercial species harvested since the 18th century. While most life stages of this species are associated with the substrate (benthic), three of the four stages of

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lobster larvae are found in the water column (pelagic) between late spring to early fall (May to October), where they are transported by surface water from offshore to coastal waters before settling to the bottom (MacKenzie and Moring, 1985). Recent work by Incze (2010) reported, based on a spatially explicit population model, that larvae stages I-III are generally found in the top 15 meters (m) of the water column concentrating in the coastal shelf (<50 m to 100 m isobaths), with vertical distribution varying depending on water column stratification. A related paper (Annis, 2005) also documented that post-larvae (stage IV) concentrate in the upper 2 m of the water column, spending the large majority of their time near the surface (0-0.5 m) closer to shore. Consequently, an oil spill of large magnitude coinciding with peak distributions of larvae in the top few meters of the water column may have impacts on a fraction of the lobster population. While there are reasonable concerns regarding the potential impact of oil to early life stages of lobster, only a small number of studies (Capuzzo et al., 1984; Wells, 1972; Wells and Sprague, 1976) have documented their sensitivity to physically dispersed oil.

Modeled Expected Environmental Concentrations. For the purpose of this exercise, two scenarios for this ***drill*** are run to characterized potential oil concentrations associated with this release using the General NOAA Operational Modeling Environment (GNOME) (Beegle-Krause, 2001; NOAA/ERD, 2013): 1) a scenario allowing the released oil to disperse physically without the use of dispersants; and 2) a scenario treating the released oil with dispersants, under the assumption that 50% of the oil is effectively dispersed. Note that this is an ***extreme*** case of dispersant effectiveness, and is intended here to provide a worst-case exposure condition of aquatic organisms to chemically dispersed oil. While dispersant effectiveness under field conditions is highly variable, dispersant effectiveness has been reported to vary between 5% and 30% (NRC, 2005). The hypothetical spill of Kuwait oil is assumed to take place offshore in an area between the 60 and 200 m isobaths.

GNOME was run under the following environmental conditions.

- Light to Medium crude (API 34)
- Environmental conditions:
    - Wind: variable, range 2 to 12 knots from various directions
    - Mixed layer: 10 m depth
    - Breaking wave height: variable, range 0.009 to 0.33 m
    - Contour depth: 0 to 5 m

GNOME modeled oil trajectories (Figures 5 and 6) showed that physically dispersed oil would impact coastal shorelines north east of Blacks Harbour within 48 hours post release, with large quantities of oil entering the western section of Bay of Fundy 48 to 96 hours post release. At 96 hours post release, oil would reach south eastern sections of the Bay (e.g., Roosevelt Campobello International Park, Clark Gregory Nature Preserve). By comparison, modeled trajectories of the oil chemically treated with dispersants showed generally the same trends, except that the extent of shoreline oiling would be substantially lower. However, larger amounts of oil are entrained in the top few meters of the water column. Under the chemically dispersed scenario, peak oil concentrations in the water column would be localized north of Grand Manan Island.

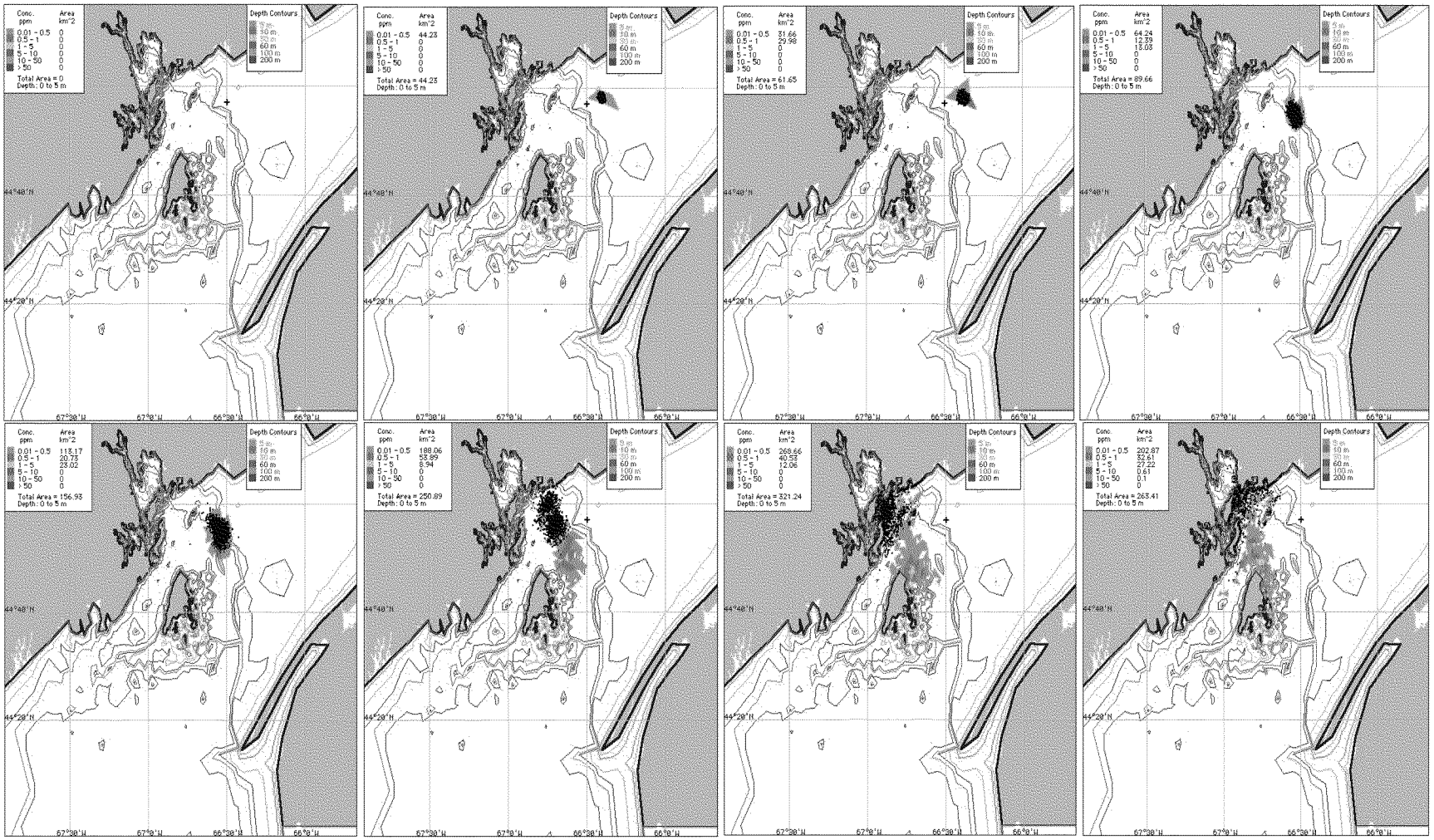

Figure 5. Spill trajectory snap shots of a physically dispersed plume of Kuwait crude oil (1.47 million gal) released into Bay of Fundy by the tank vessel *M/T NERITINA* ***(drill)***. Top and bottom, and left to right, represent GNOME model outputs 0, 3, 6, 12, 24, 48, 72, and 96 hours post release. Colors represent modeled oil concentrations in the top 5 m of the water column. Data provided by A. Mearns, NOAA ERD.

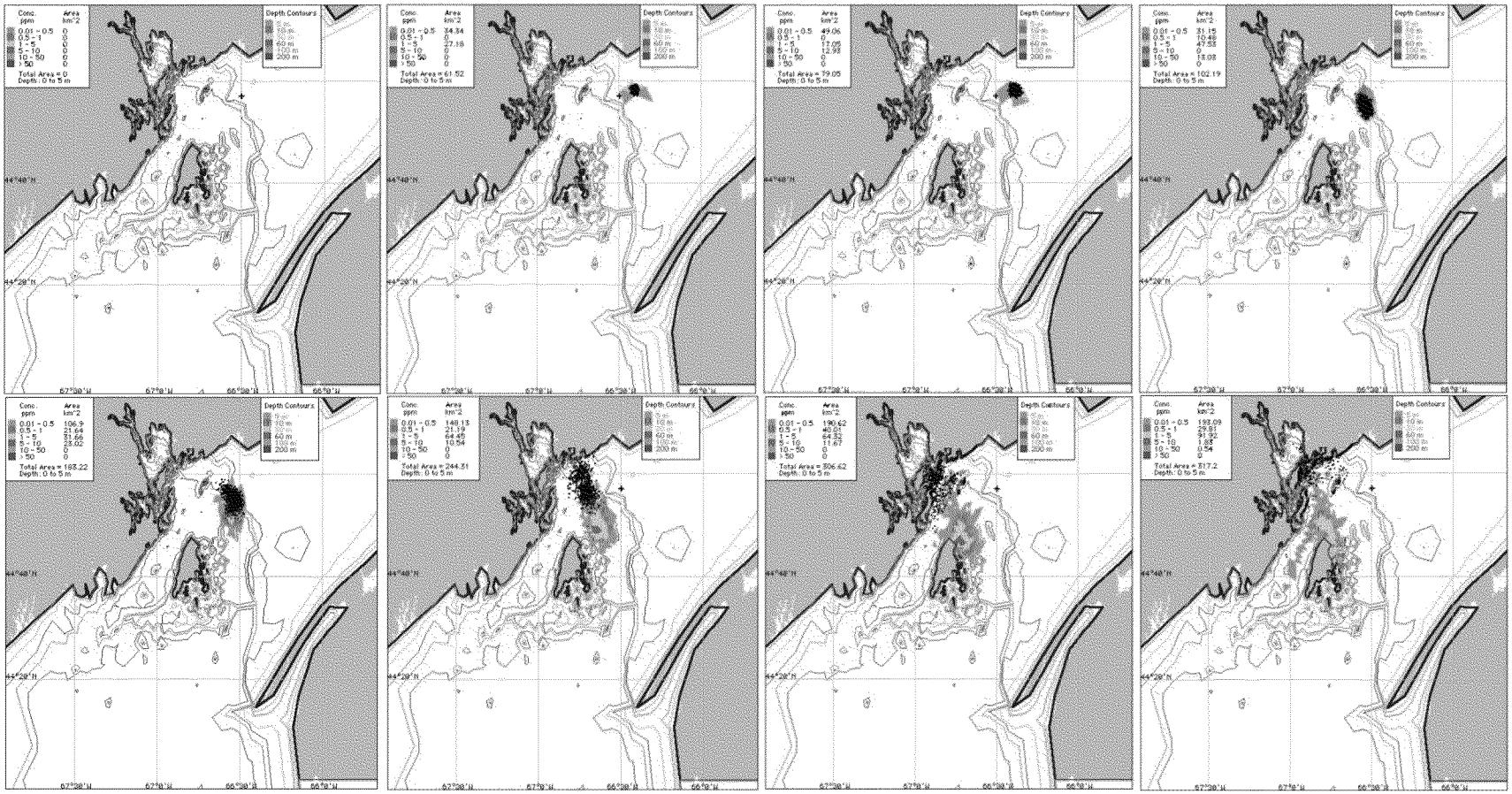

Figure 6. Spill trajectory snap shots of a chemically dispersed plume of Kuwait crude oil (1.47 million gal) released into Bay of Fundy by the tank vessel *M/T NERITINA* ***(drill)***. Top and bottom, and left to right, represent GNOME model outputs 0, 3, 6, 12, 24, 48, 72, and 96 hours post release. Colors represent modeled oil concentrations in the top 5 m of the water column. Data provided by A. Mearns, NOAA ERD.

Oil budgets for the two scenarios of this ***drill*** (Figures 7) indicated that physically dispersed oil would remain in large quantities floating on the water surface during the first 24 hours post release (48% of the oil released), following by large quantities of oil stranding on shoreline habitats (up to 25% of the oil released) between 48 and 96 hours post release. Under this scenario, 37% of the oil would evaporate, and up to 30% would be physically dispersed into the water column. By comparison, a relatively small amount of the released oil (4%) would be present on the water surface following chemical treatment of oil slicks. Under this scenario, a large proportion of the released oil (60%) would disperse into the water column (mostly into the top 10 m of the water column) within the 24 hours post release, but a relatively small proportion (13%) would impact coastal shorelines. Under this scenario, 19% of the oil would dissipate via evaporation.

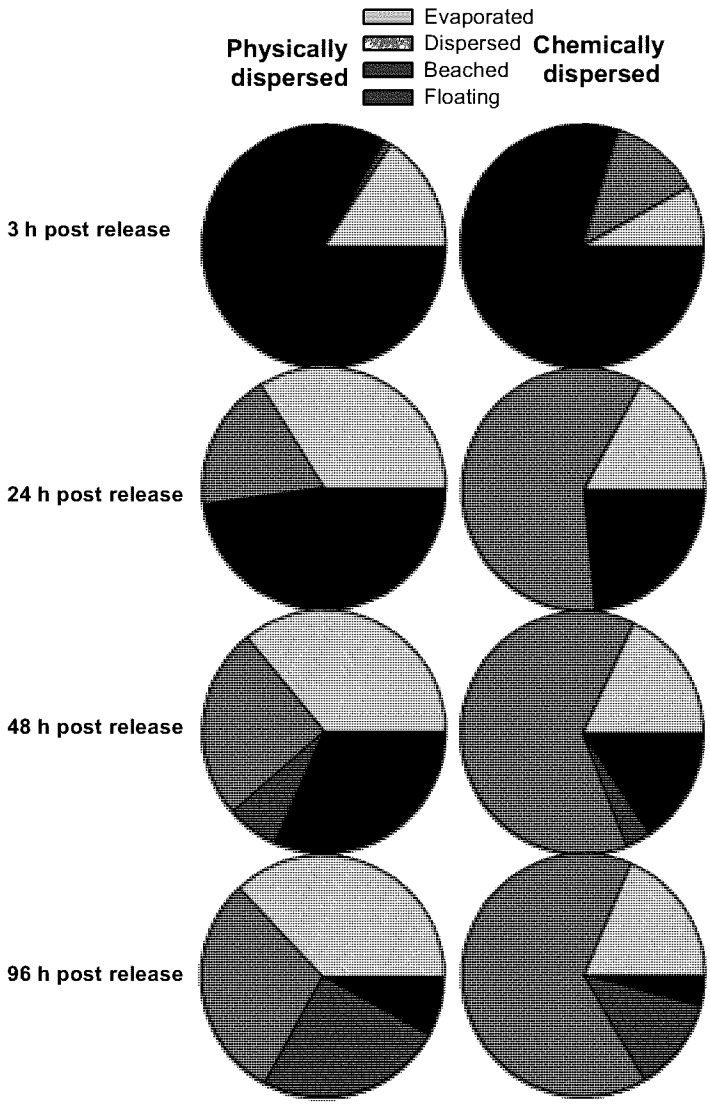

Figure 7. Oil budgets comparison as a function of time between the physically and chemically dispersed scenarios from a release of Kuwait crude oil (1.47 million gal) into Bay of Fundy by the tank vessel *M/T NERITINA* ***(drill)***. Note that the chemically dispersed scenario assumes an extremely high dispersant effectiveness (50%), which is intended here to provide a worst-case exposure condition to aquatic organisms. Data from GNOME provided by A. Mearns, NOAA ERD.

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Two summary statistics are obtained from GNOME to characterize oil concentrations for this ***drill***. These are the average and maximum (worst-case) concentrations in the top 5 m of the water column for each 30 min interval over the entire model run period (0 to 96 hours). Average and maximum (worst-case) modeled oil concentrations in the water column (covered in detail in a later section) under the physically dispersed scenario are generally low (Figure 8) (Average: mean 0.29 mg/L, median, 0.30 mg/L, maximum 0.43 mg/L; Maximum (worst-case): mean 1.29 mg/L, median, 1.54 mg/L, maximum 2.19 mg/L). By comparison, the average and maximum modeled oil concentrations in the water column under the chemically dispersed scenario are in the 1.5- 3 mg/L range, with some exceptions (Average: mean 0.79 mg/L, median, 0.89 mg/L, maximum 1.97 mg/L; Maximum: mean 2.39 mg/L, median, 2.56 mg/L, maximum 3.62 mg/L).

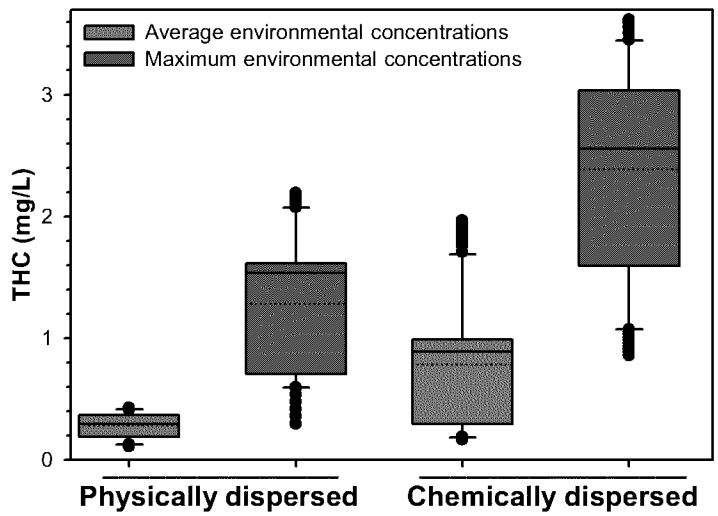

Figure 8. General box-plot overview of the expected oil concentrations of physically and chemically dispersed scenarios from a release of Kuwait crude oil (1.47 million gal) into Bay of Fundy by the tank vessel *M/T NERITINA (**drill**)*. Data from GNOME. Note that the chemically dispersed scenario assumes an ***extremely high*** dispersant effectiveness (50%), and intended here to provide a worst-case exposure condition to aquatic organisms. Oil concentrations are the average and maximum concentrations in the top 5 m of the water column for each 30 min interval over the entire model run period (0 to 96 hours). The length of the box represents the distance between the 25th and the 75th percentile concentrations, while the whiskers represent the 5th and 95th percentile concentrations. The solid and dashed horizontal lines in the box represents the median and mean respectively. The closed circles indicate outliers.

Estimated Environmental Concentrations of Concern. A query was performed in DTox to facilitate the understanding of the potential impact of physically and chemically dispersed oil on lobster larvae. To ensure reproducibility of the analyses presented here, a complete list of relevant fields queried and selected in DTox is provided below (Figure 9):

- Query #1: Life stage – embryos, larvae, juvenile; Habitat – water column; Taxonomic group – fish and crustaceans; Dispersant/Oil Treatment – Oil only, and Dispersant and Oil; Exposure duration – 96-hours (*assumed to be a worst case exposure*); Exposure conditions – Spiked, Spiked-flow-through; Endpoint metric – LC50, EC50; Effects

concentration analyte – All options containing Total Hydrocarbon Content (THC); Concentration –Measured; Paper Applicability– Moderate, High

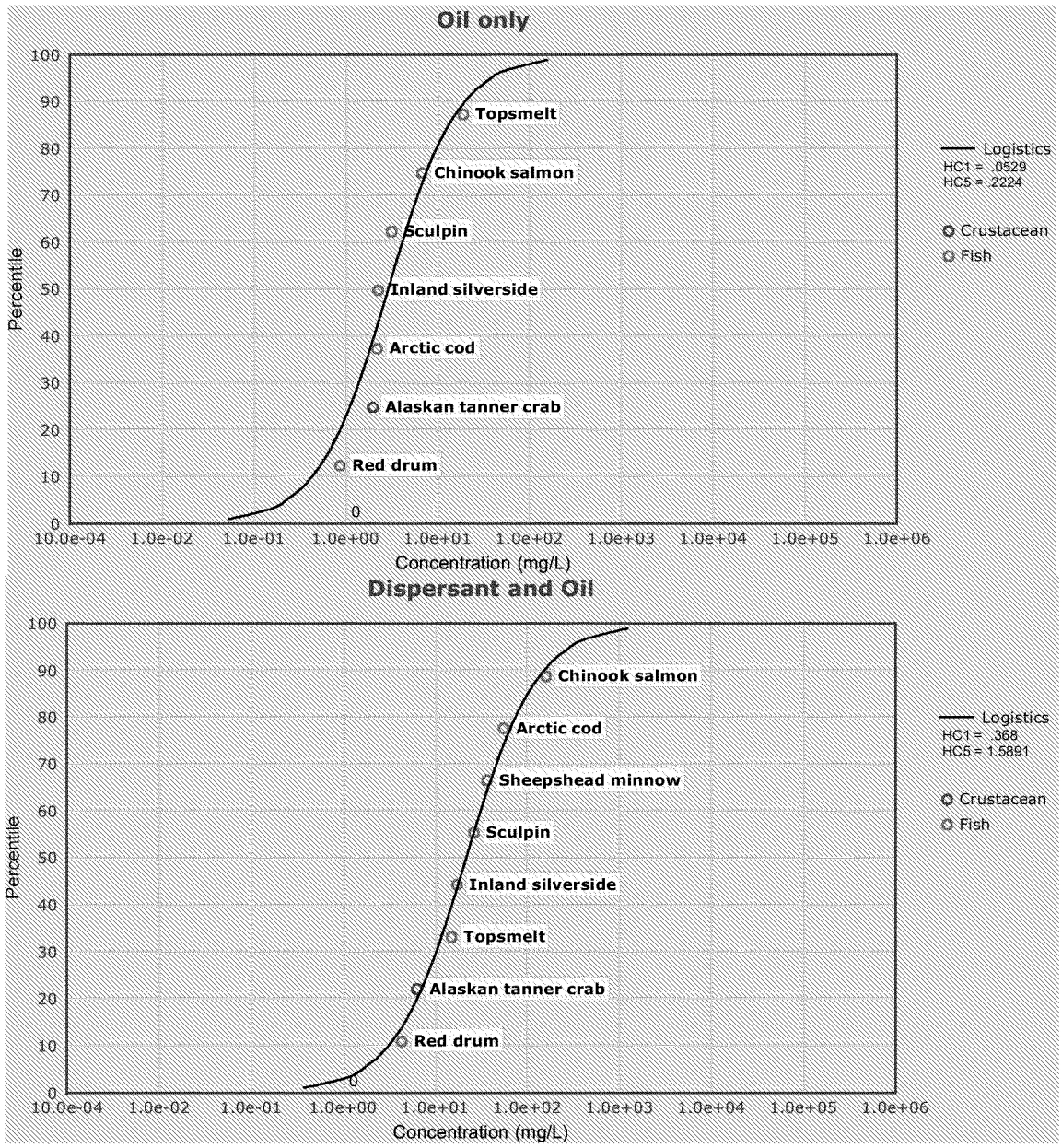

Figure 9. SSD generated following a data query in DTox for the ***drill*** in Bay of Fundy involving the tank vessel *M/T NERITINA*.

For the purpose of this ***drill***, the SSD with the most conservative 5 percentile hazard concentration (HC5=0.22 mg/L) (Figure 9, top) is used in further interpretations. Note that the only toxicity data available for larvae of the American lobster are from Wells and Sprague (1976) who reported a 96-h LC50 (based on measured reported concentrations) of 0.86 mg/L to first-stage larvae. HC values of the most conservative plot are also protective of first-stage larvae.

Potential Environmental Impacts. Average and maximum (worst-case) oil concentrations for the physically dispersed ***drill*** scenario overlap 5% and 40%, respectively, of the most conservative 96h-SSD (Figure 10). A different pattern is observed with the ***drill*** scenario involving chemical dispersion of the released oil. Average and maximum (worst-case) oil concentrations for the chemically dispersed scenario overlap 20% and 60%, respectively, of the most conservative 96h-SSD. Under the chemical dispersion scenario, 60% and 97% of the average and maximum (worst-case) oil concentrations, respectively, exceeded the HC5. Exposures above the HC5 are limited to the first 60-70 hours post release for the average scenario, and >90 hours post spill for the maximum oil concentrations scenario. All of these exceedances are limited to the top 10 m of the water column, mostly within the top 2 m (data not shown).

While these comparisons are useful, without a spatial context these can lead to overestimation of risks. The areal extent of the water surface with modeled oil concentrations is also further analyzed for the chemically dispersed scenario. As shown in Figure 11, the areal extent of the concentration bracket exceeding the HC5 (0.5-1 mg/L, 1-5 mg/L and >5 mg/L) grew from 27.18 km^2 3 hours post release to 124 km^2 120 hours post release. By contrast, most of the areal extent of the impacted water surface had concentrations in the 0.01-0.5 mg/L range (range: 34 km^2 3 hours post release to 193 km^2 120 hours post release). As shown in this exercise, the area of potential impact is relatively small (0.07% of the Gulf of Maine/Bay of Fundy system, 180,000 km^2) and concentrated into an area 24 times the size of a standard football field. This information (and Figure 7) demonstrate that while there is an increased risk to water column organisms from dispersant use to mitigate the impacts of this particular ***drill*** (albeit concentrated into a relatively small area and to depths <10 m), the greatest environmental tradeoff is the reduced impact to shoreline habitats (physically vs. chemically dispersed oil on shorelines, 368,088 gal vs. 183,456 gal, respectively), and reduced amounts of floating oil (physically vs. chemically dispersed oil on water surface 117,306 gal vs. 60,270 gal, respectively) which can pose adverse risks to surface marine species (e.g., birds and marine mammals).

As mentioned before, one of the main resources of concern is the American lobster, which under this spill scenario may be exposed to potentially toxic oil concentrations in the top few meters of the water column. The extent of potential adverse lethal and sublethal effects to this species and its local population depends on both the encounter rate of oil at concentrations above those assume to cause adverse effects, and exposure duration to those oil concentrations. Under the assumption that larvae are evenly distributed in the top 10 m of the entire Bay of Fundy area, and assuming that the entire area with concentrations ≥0.01 mg/L (physically dispersed scenario1,188 km^2; chemically dispersed scenario 1,294 km^2) would overlap the distribution of larvae, an estimated 0.7% of the lobster larvae in the entire Bay of Fundy would encounter oil in the water column.

While potential toxicological consequences to water column organisms may be expected, these assessments are conservative as the benchmark used here is biased towards overprotection or marine species (i.e., based on 96-h exposure toxicity data). This degree of conservatism added to the fact that oil biodegradation is not taken into account suggests that oil concentrations would likely be lower than those predicted by the GNOME model.

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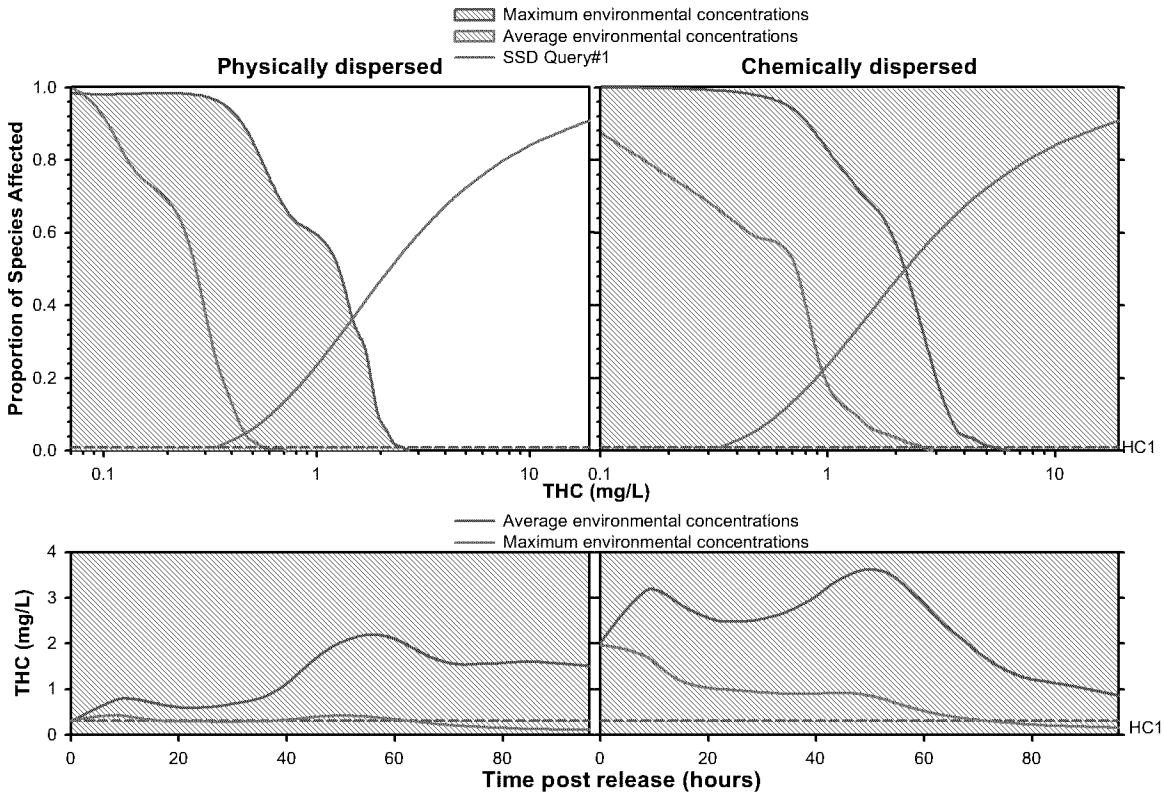

Figure 10. Cumulative average and maximum (worst-case) modeled oil concentrations relative to 96 h-SSDs (top), and average and maximum modeled oil concentrations as a function of time post release for a physically (left) and chemically dispersed (right) plume of a Kuwait crude oil into Bay of Fundy by the tank vessel M/T NERITINA (***drill***). As a reference, the benchmark for this drill is HC5=0.22 mg/L

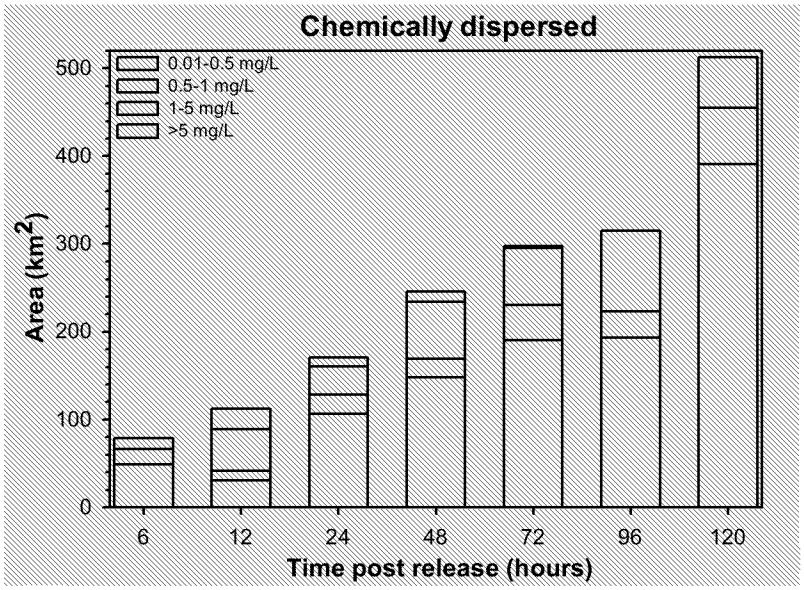

Figure 11. Water surface area impacted by a spill of Kuwait crude oil (1.47 million gal) into Bay of Fundy (***drill***), as a function of time post release (hours), and average oil concentrations. As a reference, the benchmark for this drill is HC5=0.22 mg/L.

4.3.2 Drill 2: Area offshore from Charleston Harbor, South Carolina

Spill scenario (Drill). On May 23, 2013 at 5:00 pm EDT a spill of 5,000 bbl (210,000 gal) of Qua Iboe Nigerian Crude is released offshore from Charleston Harbor, South Carolina. Qua Iboe Nigerian Crude (API 34) is a light to medium weight crude oil, which may coat intertidal habitats, as well as wildlife on the water surface. The oil may also result in water column and benthic impacts if mixed into the water column by waves, or if it strands in large amounts in shallow, sheltered areas with limited water exchange.

Resources at Risk. During spring and summer, shoreline habitats along the South Carolina coast support a high number of nesting seabirds, and beaches provide nesting habitat for several species of sea turtles. Marshes in the area provide important habitat for a variety of shorebirds, as well as terrestrial and aquatic mammals (mink, river otter, beaver, and raccoon). Nearshore and offshore areas also support productive commercial fisheries for fish and invertebrate species. Because of the ecological importance of nearshore waters to numerous marine species, the use of dispersants is not taken lightly as there are several federally threatened and endangered species (protected under the Endangered Species Act), as well as species of special concern, and species of local significance. These biological resources of concern are summarized in Table 4.

Table 4. Biological resources at risk from a release of oil off Charleston Harbor, South Carolina, with focus on nearshore/offshore waters. U.S. Status: FT = Federal threatened; FE = Federal endangered; ST = State threatened; SE = State endangered, SC= State species of special concern.

Species Group	Species Subgroup (Status)	Seasonal Presence	Comments
Birds	American oystercatchers		Largest wintering concentration on the east coast
	Bufflehead		Present in coastal and offshore areas
	Brown pelicans		Present in coastal and nearshore areas
	Cormorants		
	Great blue heron	Nesting peak May-Aug	
	Gull-billed terns and	Nesting peak Apr-Aug	
	Black skimmers	Nesting peak Apr-Aug	
	Least tern (FE; ST)		Present in marshes, and on tidal flats in the area
	Piping plover (FT; ST)		Most frequently found during winter
Reptiles	Green sea turtle (FE; SE)	Present year-round, peak Apr-Dec Nesting May-Aug Hatching July-Oct	Found in offshore waters
	Leatherback sea turtle (FE; SE)	Present year-round, peak Apr-Dec Nesting Mar-Jul Hatching May-Oct	Present in nearshore and offshore waters
	Loggerhead sea turtle (FT; ST)	Present year-round, peak Apr-Dec	Present in nearshore and offshore waters

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Species Group	Species Subgroup (Status)	Seasonal Presence	Comments
		Nesting Jun-Nov Hatching Jul-Dec	
Marine mammals	Bottlenose dolphin	Present year-round, Breeds year-round	Found in shallow nearshore waters and offshore waters
	Mink whale		Most frequently found in waters over the continental shelf. Occasionally present
	Humpback whale (FE; SE)		Most frequently found in waters over the continental shelf. Occasionally present
	North Atlantic right whale (FE)	Calving Nov-Mar	Found in shallow nearshore waters
Fish	Atlantic croaker	Larvae and juveniles may be present	Most frequently found in tidal creeks
	Atlantic menhaden	Eggs/larvae/post-larvae may be present	Adults most frequently found in offshore waters throughout the water column
	Red drum	Larvae and juveniles may be present	Adults most frequently found in coastal waters
	Red snapper	Eggs/larvae Jun-Oct Juveniles may be present	
	Shortnose sturgeon (FE)		Found in coastal rivers
	Spanish mackerel		Most frequently found in coastal and offshore waters
	Summer flounder	Larvae and juveniles may be present	Adults most frequently found in coastal waters
	Southern flounder	Larvae and juveniles may be present	Adults most frequently found in coastal waters
	Spot	Larvae and juveniles may be present	Adults most frequently found in coastal waters
Invertebrates	American oysters		Spawn in tidal creeks and on sheltered tidal flats
	Blue crab	Larvae and juveniles may be present	Found in offshore waters
	Brown shrimp	Eggs/larvae may be present Spawning Jan-Dec	Found in offshore waters
	Pink shrimp		Found in offshore waters. Not very common.
	Spiny lobster		Found in offshore waters
	Stone crab	Spawning Mar-Oct, peak May-Aug Larvae and juveniles may be present	Adult oyster, including females incubating eggs, found on bars and mud flats
	White shrimp	Spawning May-Jun	Found in offshore waters
		Larvae/juveniles may be present	

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While the area off South Carolina harbors a high diversity of aquatic species, their exposure to physically and chemically dispersed oil depends on their spatial distribution and on their habitat distribution within the water column. Consequently, the primary resources of concern are those commonly found offshore at the water surface or in the upper few meters of the water column. Specific examples include adults and early life stages of commercially important free-swimming shellfish (brown shrimp, white shrimp, and blue crab), and fishery resources that spawn in the water column (e.g., Atlantic menhaden).

Modeled Expected Environmental Concentrations. For the purpose of this exercise, two scenarios for this ***drill*** are run to characterize potential oil concentrations associated with this release using GNOME) (Beegle-Krause, 2001; NOAA/ERD, 2013): 1) a scenario allowing the released oil to disperse physically without the use of dispersants; and 2) a scenario treating the released oil with dispersants, under the assumption that 80% of the oil is effectively dispersed. Note that this is an ***extremely high*** case of dispersant effectiveness, and is intended here to provide a worst-case exposure condition of aquatic organisms to chemically dispersed oil. While dispersant effectiveness under field conditions is highly variable, dispersant effectiveness has been reported to vary between 5% and 30% (NRC, 2005).

GNOME was run under the following environmental conditions.

- Light to Medium crude (API 34)
- Environmental conditions:
  - Wind: 15 knots from the South
  - Mixed layer: 5 m depth
  - Breaking Wave Height: 1 m
  - Contour depth: 0 to 5 m

GNOME modeled oil trajectories (Figures 12 and 13) showed that physically dispersed oil would impact coastal shorelines north east of the harbor (e.g., Sullivan's Island and Isle of Palms) within 24 hours post release, with large quantities of oil entering Charleston Harbor between 24 and 48 hours post release. Coastal habitats south west of the harbor (e.g., Morris Island and Folly Beach) would be oiled >24 hours post release. By comparison, modeled trajectories of the oil that is chemically treated with dispersants showed generally the same trends, except that the extent of shoreline oiling would be substantially lower. However, larger amounts of oil are entrained in the top few minutes of the water column.

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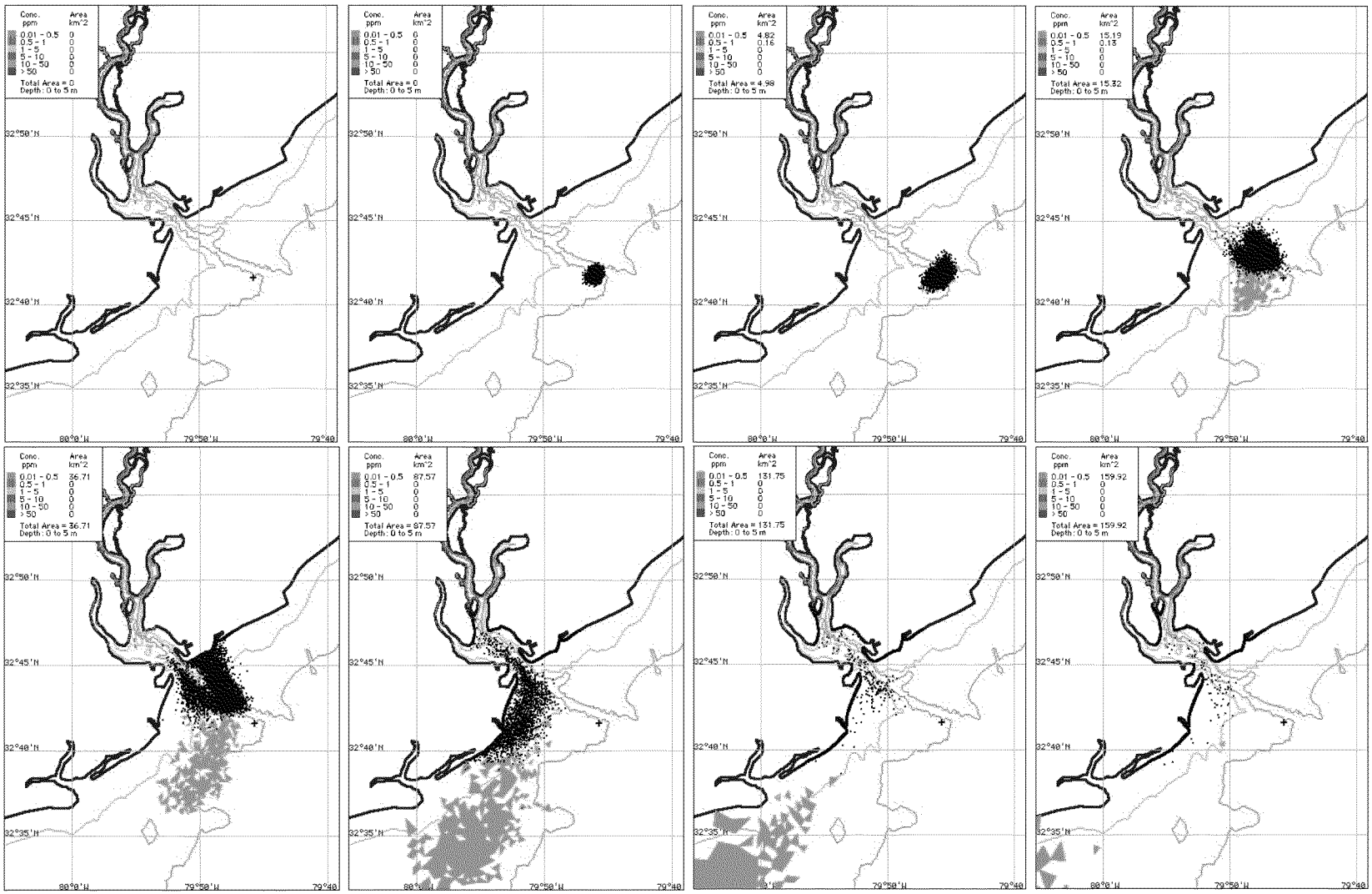

Figure 12. Spill trajectory snap shots of a physically dispersed plume of Qua Iboe Nigerian crude oil (210,000 gal) (***drill***) released offshore from Charleston Harbor. Top and bottom, and left to right, represent GNOME model outputs 0, 3, 6, 12, 24, 48, 72, and 96 hours post release. Colors represent modeled oil concentrations in the top 5 m of the water column. Data provided by A. Mearns, NOAA ERD.

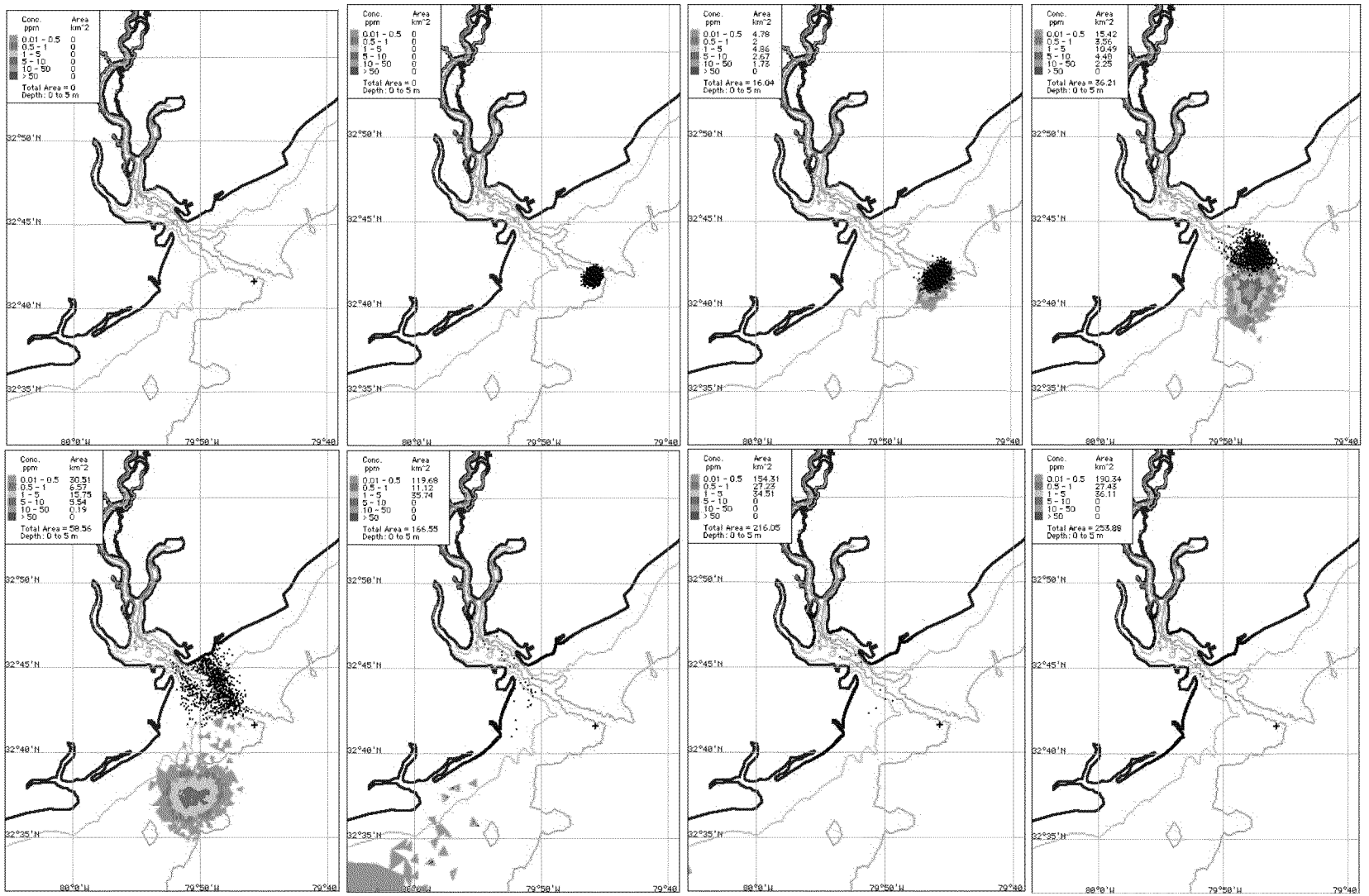

Figure 13. Spill trajectory snap shots of a chemically dispersed plume of Qua Iboe Nigerian crude oil (210,000 gal) (***drill***) released offshore from Charleston Harbor, assuming an extremely high dispersant effectiveness (80%). Top and bottom, and left to right plots represent GNOME model outputs 0, 3, 6, 12, 24, 48, 72, and 96 hours post release. Colors represent modeled oil concentrations in the top 5 m of the water column. Data provided by A. Mearns, NOAA ERD.

Oil budgets for the two scenarios of this ***drill*** (Figure 14) indicated that physically dispersed oil would remain in large quantities floating on the water surface during the first 24 hours post release (>50% of the oil released), following by large quantities of oil stranding on shoreline habitats (>30% of the oil released) between 48 and 96 hours post release. Under this scenario, 35% of the oil would evaporate, and <5% would be physically dispersed into the water column. By comparison, a relatively small amount of the released oil (14%) would be present on the water surface following chemical treatment of oil slicks. Under this scenario, a large proportion of the released oil (65%) would disperse into the water column (mostly into the top 5 m of the water column) within the 24 hours post release, but a relatively small proportion (11%) would impact coastal shorelines. Under this scenario, 20% of the oil would dissipate via evaporation.

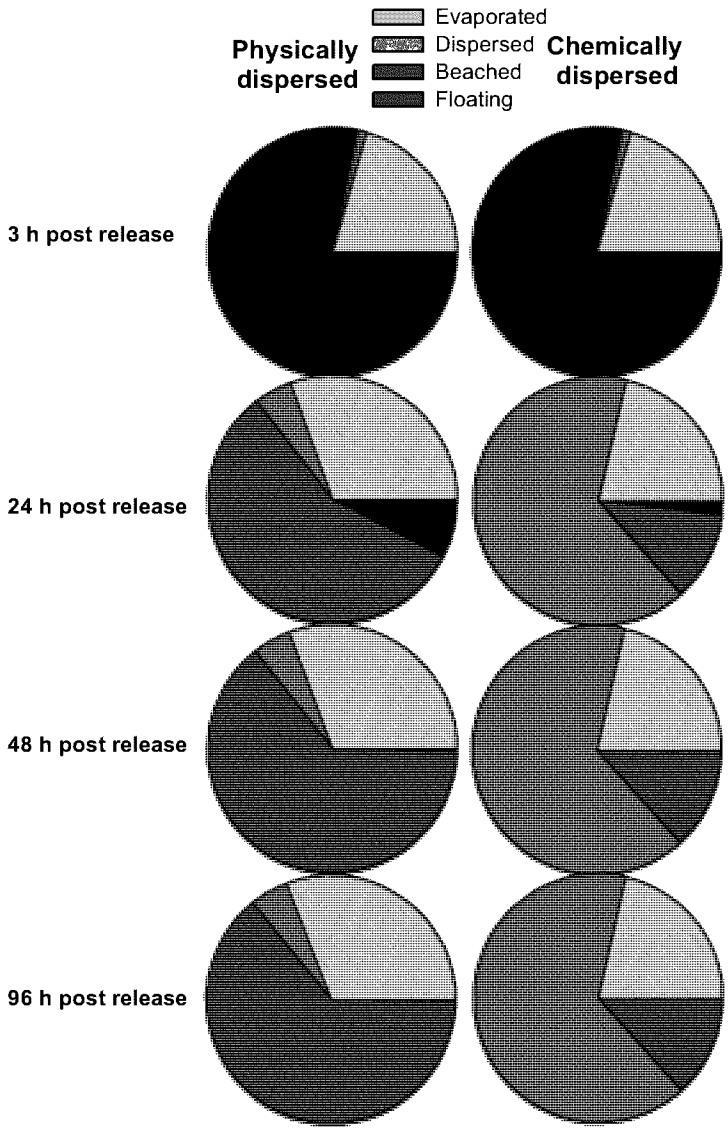

Figure 14. Oil budgets comparison as a function of time between the physically and chemically dispersed scenarios from a release of Qua Iboe Nigerian crude oil (210,000 gal) (***drill***) offshore from Charleston Harbor. Note that the chemically dispersed scenario assumes an extremely high dispersant effectiveness (80%)%), which is intended here to provide a worst-case exposure condition to aquatic organisms. Data from GNOME provided by A. Mearns, NOAA ERD.

Two summary statistics are obtained from GNOME to characterize oil concentrations of hydrocarbon for this ***drill***. These are the average and maximum (worst-case) concentrations in the top 5 m of the water column from each 30 min interval over the entire model run period (0 to 96 hours). Average and maximum (worst-case) modeled oil concentrations in the water column (cover on detailed in a later section) under the physically dispersed scenario are generally low (Figure 15) (Average: mean 0.07 mg/L, median, 0.05 mg/L, maximum 0.28 mg/L; Maximum (worst-case): mean 0.374 mg/L, median, 0.27 mg/L, maximum 0.73 mg/L). By comparison, the average and maximum (worst-case) modeled oil concentrations in the water column under the chemically dispersed scenario are in the 1- 3 mg/L range, with some exceptions (Average: mean 0.96 mg/L, median, 0.63 mg/L, maximum 3.2 mg/L; Maximum (worst-case): mean 2.92 mg/L, median, 1.59 mg/L, maximum 13.15 mg/L).

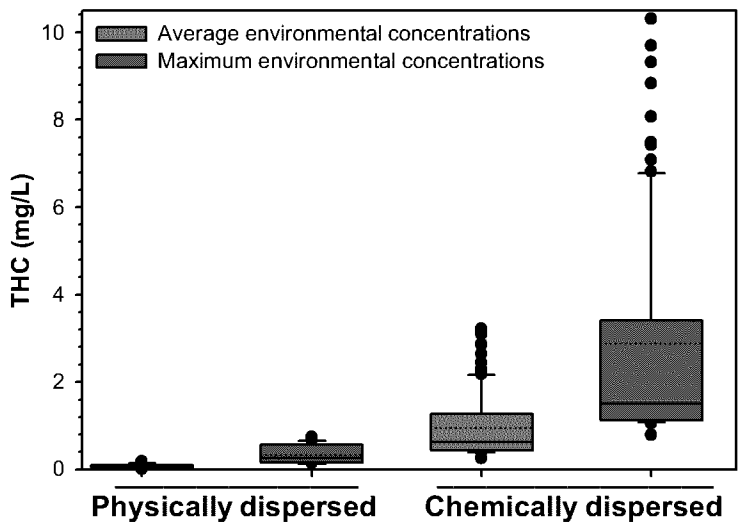

Figure 15. General box-plot overview of the expected oil concentrations physically and chemically dispersed scenarios from a release of Qua Iboe Nigerian crude oil (210,000 gal) (***drill***) offshore from Charleston Harbor. Note that the chemically dispersed scenario assumes an ***extremely high*** dispersant effectiveness (80%), and intended here to provide a worst-case exposure condition to aquatic organisms. Oil concentrations are the average and maximum concentrations in the top 5 m of the water column for each 30 min interval over the entire model run period (0 to 96 hours). The length of the box represents the distance between the 25th and the 75th percentile concentrations, while the whiskers represent the 5th and 95th percentile concentrations. The solid and dashed horizontal lines in the box represents the median and mean respectively. The closed circles indicate outliers.

Estimated Environmental Concentrations of Concern. Two queries are performed in DTox to facilitate the understanding of the potential impact of physically and chemically dispersed oil on species of interest off Charleston Harbor, South Carolina: selected species query, and shrimp query regardless of their global distribution. To ensure reproducibility of the analyses presented here, a complete list of relevant fields queried and selected in DTox is provided below (Figure 16):

- Query #1: Species – all shrimp-like species, plus sheepshead minnow, gulf killifish and longnose killifish (species of the genus, *Fundulus*), Inland silverside, and Red drum (25 species total); Exposure duration – 96-hours (*assumed to be a worst case exposure*); Endpoint metric – LC50; Oil name – All light and medium oils; Dispersant name – Corexit 9500, EC9500A, 9527, and EC9527A; Effects concentration analyte – all options containing Total Hydrocarbon Content (THC); Concentration – Measured; Paper Applicability – Moderate, High

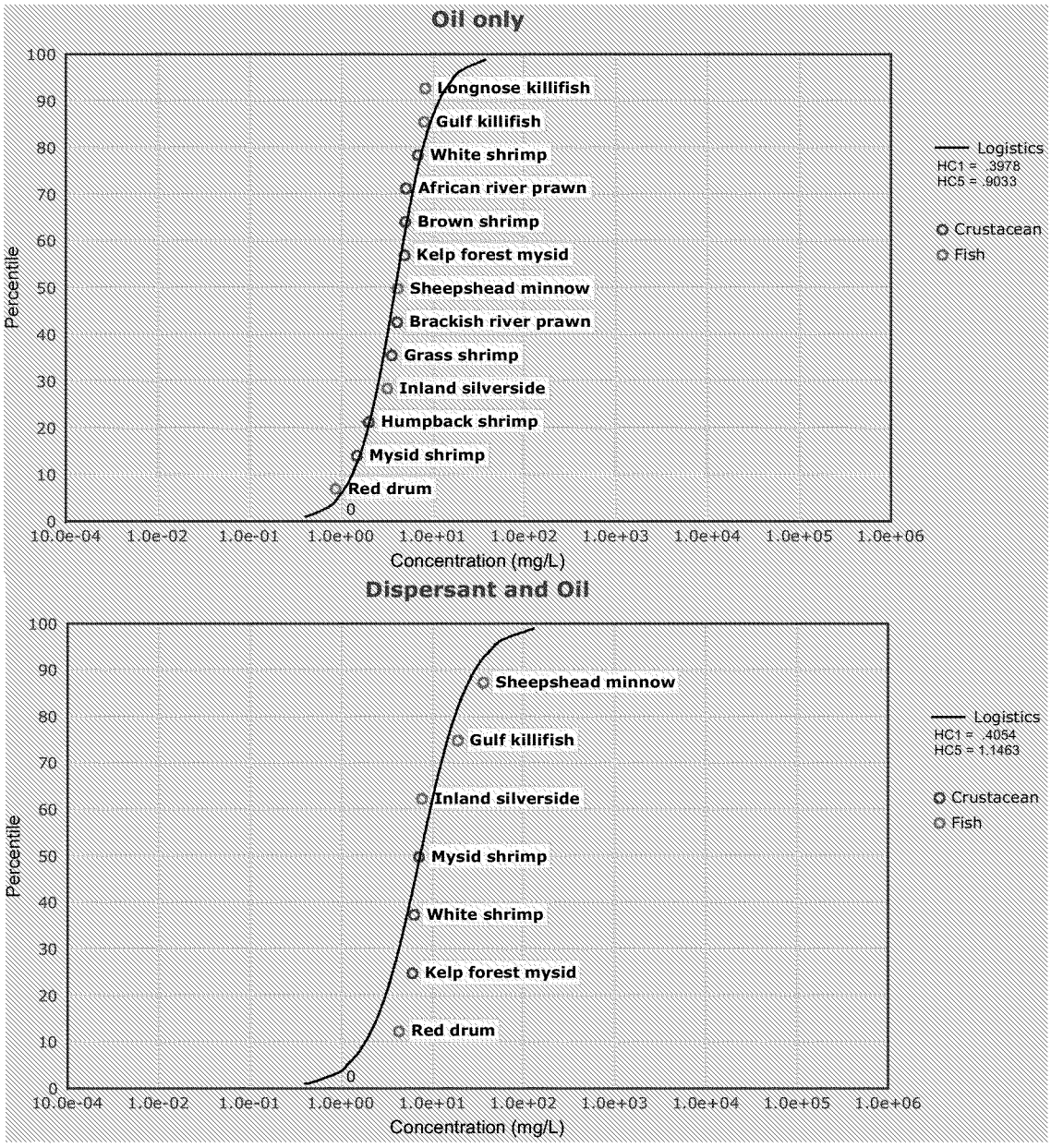

Figure 16. SSD generated following a data query in DTox for the ***drill*** off Charleston Harbor.

For the purpose of this ***drill***, the SSD with the most conservative hazard concentration (HC1=0.4 mg/L) (Figure 16, top) is used in further interpretations.

Potential Environmental Impacts. Average and maximum (worst case) oil concentrations for the physically dispersed ***drill*** scenario overlap 0% and 10%, respectively, of the most conservative 96h-SSD (Figure 17). A different pattern is observed with the ***drill*** scenario involving chemical dispersion of the released oil. Average and maximum (worst case) oil concentrations for the chemically dispersed scenario overlap 40% and 70%, respectively, of the most conservative 96h-SSD. Under the chemical dispersion scenario, 60% and 95% of the average and maximum (worst case) oil concentrations, respectively, exceeded the HC1. Exposures above the HC1 are limited to the first 40-50 hours post release for the average scenario, and >90 hours port spill for the maximum (worst case) oil concentrations scenario. All of these exceedances are limited to the top 5 m of the water columns (data not shown).

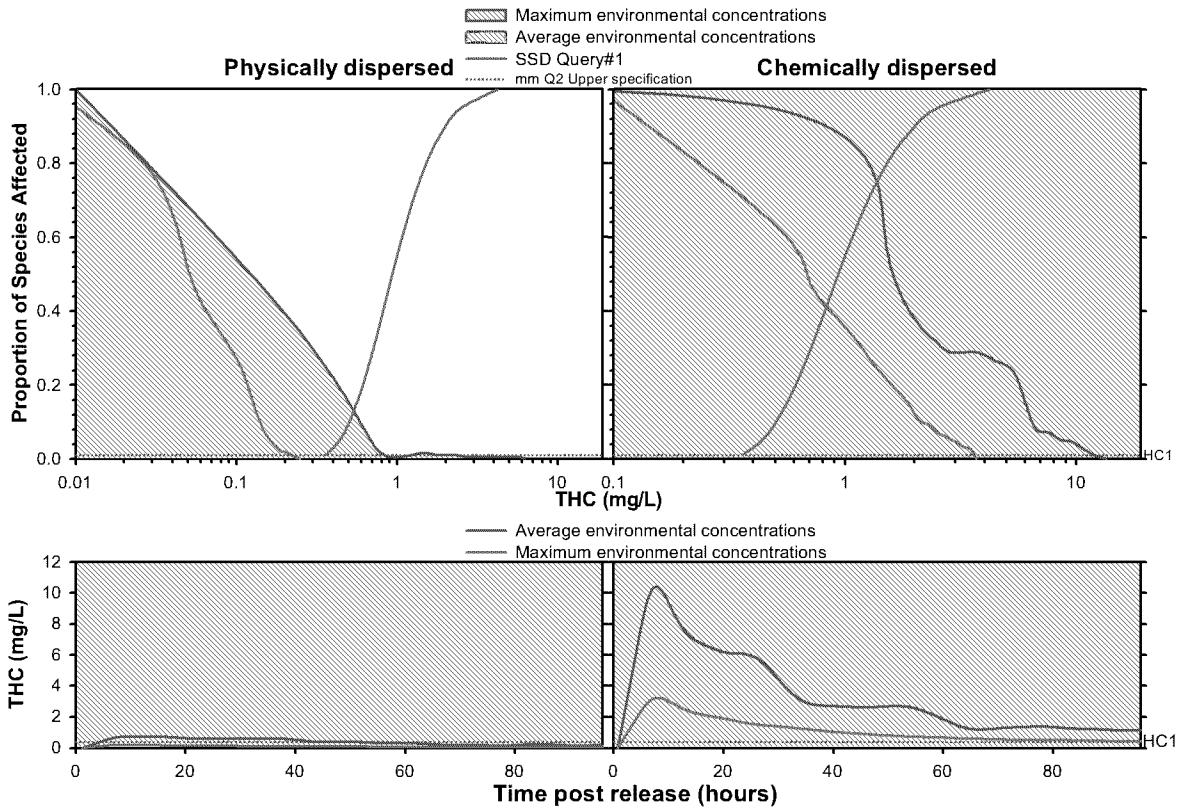

Figure 17. Cumulative average and maximum (worst-case) modeled oil concentrations relative to 96 h-SSDs (top), and average and maximum modeled oil concentrations as a function of time post release for a physically (left) and chemically dispersed (right) plume of a Qua Iboe Nigerian Crude spill off Charleston Harbor, SC (***drill***). As a reference, the benchmark for this drill is HC1=0.4 mg/L.

While these comparisons are useful, without a spatial context, these can lead to overestimation of risks. The areal extent of the water surface with modeled oil concentrations is also further analyzed for the chemically dispersed scenario. As shown in Figure 18, areal extent of the concentration bracket containing and exceeding the benchmarks (0.5-1 mg/L, 1-5 mg/L and >5 mg/L) grew from 11 km^2 6 hours post release to 63 km^2 120 hours post release. By contrast, most of the areal extent of the impacted water surface had concentrations in the 0.01-0.5

mg/L range (range: 5 km^2 6 hours post release to 190 km^2 120 hours post release). As shown in this exercise, the area of potential impact is relatively small and concentrated into an area 12 times the size of a standard football field. To put the information above into perspective (see also Figure 14) under the physical dispersion scenario, 85 km of coastal shoreline would be directly impacted, with maximum estimated oil stranded concentrations up to 47 gallons of oil per meter of shoreline (A. Mearns, pers. comm.). By comparison, under the chemical dispersion scenario, 64 km of coastal shoreline would be directly impacted, with maximum estimated oil stranded concentrations up to 10 gallons of oil per meter of shoreline. This information, and data presented in Figure 14, demonstrate that while there is an increased risk to water column organisms from dispersant use to mitigate the impacts of this particular spill (***drill***) (albeit concentrated into a relatively small area and to depths <5 m), the greatest environmental tradeoff is the reduced impact to shoreline habitats (both on extent and degree of oiling), and reduced amounts of floating oil which can pose adverse risks to surface marine species (e.g., birds and marine mammals).

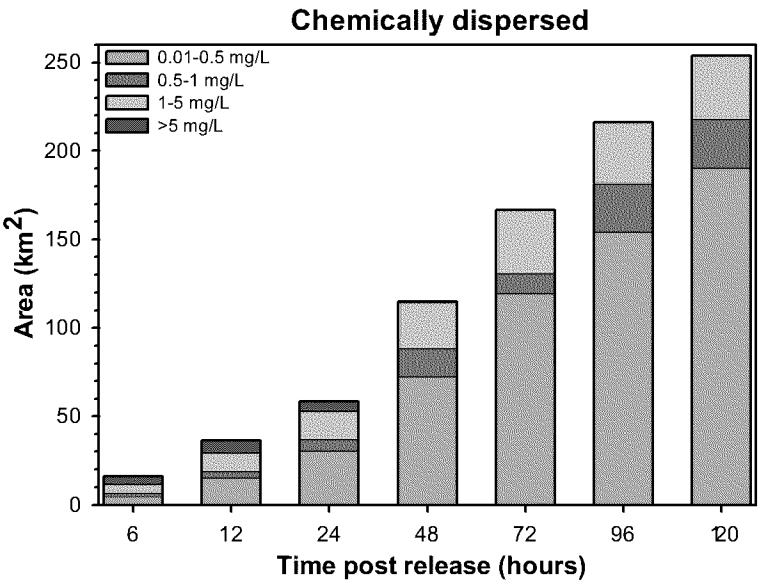

Figure 18. Water surface area impacted by a spill of Qua Iboe Nigerian Crude off Charleston Harbor, SC (***drill***), as a function of time post release (hours), and average oil concentrations. As a reference, the benchmark for this drill is HC1=0.4 mg/L.

While potential toxicological consequences may be expected from worst-case oil concentrations (e.g., maximum oil concentrations), these assessments are conservative as the benchmark used here is conservative and biased towards overprotection or marine species (i.e., based on 96 h exposure toxicity data). This degree of conservatism added to the fact that oil biodegradation is not taken into account suggests that oil concentrations would likely be lower than those predicted by the model.

5.0 Discussion and Importance to Oil Spill Response and Damage Assessment and Restoration

5.1 DTox - Data Compilation, Demonstration, and Application

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The primary intent of the exercises presented in Section 4.3 is to demonstrate the applicability of DTox as a tool to aid assessment performed during an oil spill response (spills or drills), and not to support or discourage the use of dispersants as a countermeasure to respond to off shore oil spills. Important to note is the fact that both drill scenarios involved large releases of oil and high dispersant effectiveness, leading to exceedances of benchmark values. It is also important to note that a conservative approach is used, by deriving benchmark values derived from 96-h toxicity data, which is assumed to be a worst case exposure scenario. Specific data limitations identified though drills in Section 4.3 include:

Drill #1:

- Queried data does not contain data on the species of interest (American lobster)
- There are insufficient data for Kuwait crude oil and the queried data contain only a few records for a related oil (Forties)
- Larvae and other early life stages of crustaceans are underrepresented in the database

Drill #2:

- Queried data contained toxicity data for species found in the Charleston Harbor area, including species listed in Table 4. However, queried data does not contain toxicity data for other relevant species of concern
- There are insufficient data for Qua Iboe Nigerian Crude
- Larvae and other early life stages of crustaceans are underrepresented in the database

One of the greater limitations encountered during the development of SSDs to support decision-making for these two drills is the lack of toxicity data for shorter exposures (e.g., <24 hours). Data for spiked flow-through exposures, which are intended to address the dilution that occurs in field conditions, are also limiting. These types of information are important because oil concentrations are expected to peak immediately after release, especially immediately after chemical treatment with dispersants, and these conditions are not adequately addressed in most tests for which toxicity data are available. Another great limitation is that the large majority of studies on oil toxicity typically report measured concentrations of the exposure media on the basis of petroleum hydrocarbons, without providing a detailed chemical characterization of the fractions that most contribute to toxicity, polycyclic aromatic hydrocarbons (PAHs). Despite existing data limitations, the exercises about showed that DTox provides information that can be used to inform tradeoff decisions based on the current state of knowledge.

As discussed above, one of the greatest limitations of the existing toxicity data and, consequently, on the results and applicability of this project to oil spill response and damage assessment and restoration, deals with the lack of data derived from environmentally realistically exposures. This issue is not new and has been extensively discussed in the past (Aurand and Coelho, 2005; Barron and Ka'aihue, 2003; NRC, 2005; Singer et al., 1995). Consequently, deriving toxicity data from laboratory conditions that address dilution, water mixing, and changing exposure concentrations over time, continues to be a large data gap. Equally important is the reporting of toxicity data on the basis of measured exposure concentrations (specially for a complex mixture such as oil), instead of nominal concentrations, as this is the only reliable metric that allows for appropriate characterizations of potential risks (e.g., Coelho et al., 2013; NRC, 1989, 2005). The importance of reporting measured concentrations was not taken lightly during the development of DTox, as reflected in the applicability score given to each data source.

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Another source of data uncertainty emerging from this project is related to toxicity of dispersants and physically and chemically dispersed oil to untested species (see for example Section 4.3), or to species protected under the Endangered Species Act. While lack of toxicity data on a number on important species or species of special interest is a source of concern, the approach implemented in DTox, namely the use of SSDs, can facilitate derivation of conservative benchmark values that may protect many of the untested species. As demonstrated here and in related studies using and applying SSDs in oil research (Barron et al., 2013; Bejarano et al., 2013; de Hoop et al., 2011), the use of these SSDs can provide a mechanism by which existing toxicity data can help assess risks to untested species. Another important use of SSDs (shown here and discussed in Barron et al., 2013) is that it allows for visualization of toxicity data for many standard test species, supporting the notion that these species are appropriate surrogate for many non-standard test species and untested species. However, future toxicity testing should not only focus on standard toxicity test species, but also on other test species easily reared and maintained under laboratory conditions. Additional toxicity data of value to the oil spill community and of interest for future updates of DTox also include toxicity testing on different life stages of the same species. In addition and as discussed above, toxicity data for short exposures is lacking in the literature. In Dtox, <10% of all records are derived from exposures <8 hours, while 83% of all records came from standard exposure durations used in toxicity testing (24, 48, 72, and 96 hours combined), mostly from 96 hour exposures (50% of all records).

Despite data deficiencies and uncertainties, existing toxicity data now compiled in DTox provide useful information to end-users and oil spill practitioners, so long as this information is used within the context of what is environmentally realistic to occur under field conditions. With that caveat in mind, the existing knowledge on the toxicity of dispersants and chemically dispersed oil can be useful in informing assessments and decisions regarding dispersant use.

The effectiveness, usefulness, and transferability of DTox to oil spill response are evaluated through two oil spill drills (Section 4.3), dispersant-related workshops, and dispersant-related assessment (Section 7). These exercises show that, despite existing data limitations, DTox provides information that can be used to inform tradeoff decisions based on the current state of knowledge. The data in DTox have the potential to contributed to a better understanding of the biological effects of dispersants and oil in the aquatic environment, and can provided useful information to both, environmental assessment and decision making efforts. Future efforts will focus on maintaining and updating data in DTox, and on expanding its capabilities for use by the oil spill community.

6.0 Technology Transfer

A critical step that facilitated the success of this project was the engagement of industry, government agencies, and academia in contributing to the development of this database, as well as to their transferability to several related purposes. Data currently in DTox were used to support two NOAA efforts. The first effort involved a dispersant workshop where there were discussions on the current state of knowledge regarding the toxicity of dispersants and chemically dispersed oil. Through several examples and using data primarily from DTox, concerns regarding potential toxicological effects were addressed. The second effort involved data compilation to support an oil spill drill between Canada and the U.S. (CANUSLANT, June

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17-20, 2013). Data from Dtox were used to compare the relative sensitivity of American lobster larvae to naturally and chemically dispersed oil, relative to the sensitivity of other species for which larvae data are available in DTox. This analysis showed that American lobster larvae are relatively sensitive, compared to other species of larvae, as it falls within the lower end of the SSD curve. This information was used during internal discussions within the Unified Command during the drill. Data from DTox have also been used to support the preparation of a biological assessment on the pre-approved use of dispersants. These data, transferred in the form of data summaries and figures, provided some of the scientific bases for assessments of potential adverse effects to aquatic species, included those under the Endangered Species Act. Additional efforts were undertaken to transfer this wealth of knowledge to oil spill responders including the government, industry, and academics via web-based seminars (three in total), and presentations at national conferences (see Section 7).

As discussed above, DTox has been used to facilitate the communication of risks with the public and the scientific community concerned about the use of dispersants. DTox also has the potential to contribute to discussions taking place during consensus Ecological Risk Assessment (ERA) workshops where agency scientists and responders discuss the tradeoffs of the use of dispersant and other response options. In past ERA workshops, participants had to rely on adhoc compilations of toxicity data for oil and dispersed oil.

The results of this project and the practical application of information gathered through this effort are currently being prepared in the form of manuscripts to be published in peer-review journals. Run-time versions of DTox were distributed to end-users (in the form of a downloadable file) engaged with oil spill research and response.

7.0 Achievement and Dissemination

7.1 Workshops

Bejarano A.C. and A. Mearns. The Toxicological Effects of Dispersant Use in Oil Spill Response: Facts versus Fiction. Hawaii Dispersant Workshop. Honolulu, May 5, 2013. *Number of attendees: 20.*

7.2 Off-Site Training Seminars

Bejarano A.C. DTox for Scientific Support Coordinators (NOAA, Emergency Response Division). November 5, 2013. *Number of attendees*: 10.

Bejarano A.C. DTox for End-Users (Federal and State Agencies, Industry, Academics, International end-users). December 18, 2013. *Number of attendees*: 10.

Bejarano A.C. DTox for Scientists (NOAA, Assessment and Restoration Division). January 6, 2014. *Number of attendees*: 9.

7.3 Presentation

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Bejarano, A.C, V. Chu, J. Dahlin, J. Farr. 2013. DTox: A Quantitative Database of the Toxicity of Dispersants and Chemically Dispersed Oil. SETAC. Nashville, TN, USA. (Poster)

Bejarano, A.C, V. Chu, J. Dahlin, J. Farr. 2014. DTox: A Quantitative Database of the Toxicity of Dispersants and Chemically Dispersed Oil. 2014 International Oil Spill Conference. Savannah, GA, USA. (Oral; accepted February, 2014)

7.4 Publication

Bejarano, A.C., J. Clark, G.M. Coelho. 2014. Issues and Challenges with Oil Toxicity Data and Implications for their Use in Decision Making: a Quantitative Review (accepted in *Environmental Toxicology and Chemistry*)

Bejarano, A.C, V. Chu, J. Dahlin, J. Farr. 2014. DTox: A Quantitative Database of the Toxicity of Dispersants and Chemically Dispersed Oil. Proceedings of the 2014 International Oil Spill Conference. Savannah, GA, USA. (accepted February, 2014).

Bejarano, A.C and M. Barron. 2014. Development and Practical Application of Oil and Dispersant Interspecies Correlation Models for Aquatic Species (in prep).

Bejarano, A.C, A. Mearns, V. Chu, J. Farr. 2014. Use and Application of Acute Toxicity Data in Spill Response with Focus on the Use of Dispersants (in prep).

7.5 Other Forms of Dissemination

Computer Software: Bejarano, A. C. and J. Dahlin. 2013. DTox: a Quantitative Database of the Toxicity of Dispersants and Chemically Dispersed Oil, Version 1.1 [Computer Software]. A project for the National Oceanic and Atmospheric Administration, and the University of New Hampshire's Coastal Response Research Center (Contract No. 13-034). Research Planning, Inc. Columbia SC.

Internet information dissemination http://www.researchplanning.com/projects/dtox-worldwide-quantitative-database-toxicity-dispersants-chemically-dispersed-oil/, which includes a link to a training video.

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Appendix A- Quality Assurance Quality Control Plan (Revised)

DTox: a Worldwide Quantitative Database of the Toxicity of Dispersants and Chemically Dispersed Oil

A-1 Project Description

The ability to rapidly assess the toxicity of physically and chemically dispersed oils is a goal shared by government, industry, consultants, and academic groups involved in oil spill response. One common need of the oil spill community is the unrestricted and rapid access to available toxicity data on dispersants and chemically dispersed oils. However, there are no centralized data repositories gathering decades of existing toxicity data. The end-result of this project, the Dispersant and Chemically Dispersed Oil Toxicity Database (DTox), addresses that shared need of the oil spill community, and contributes to a better understanding of the biological effects of dispersants and dispersed oil. This quantitative data compilation provides the basis for a more thorough assessment of levels of concern for dispersants and chemically dispersed oil, and helps improve risk estimates during oil spills or drills by allowing the selection of data that most closely match the needs of the end-user. The ultimate goal of this effort is the synthesis of information in a meaningful way to improve scientific decision-making as well as to provide rapid access to centralized toxicity data. To meet the goals of this project, a Quality Assurance Plan was designed to meet the following objectives:

- Outline the procedures and data management implemented during the development of this project to ensure that data selection and data entry, storage, and management are of high quality;
- Provide a means by which the quality of information produced can be maintained throughout the project;
- Provide a sound basis for documenting, evaluating, and verifying the accuracy of data selection and entry;
- Provide guidelines for the preparation and review of project plans and reports; and
- Provide the means that would allow the end-user assess the quality of data compilation efforts.

A-2 Objectives

The main objectives of this project are to identify, evaluate, compile, and integrate all available worldwide toxicity data on dispersants and chemically dispersed oil generated under laboratory and field conditions, and to generate an interactive tool that can assist the oil spill response community in management decisions regarding the use of dispersants.

The specific objectives of this project are to:

1. Identify documents, peer-review and gray literature (e.g., field, laboratory, mesocosm, accidental oil spills), reporting the toxicological effects (acute and chronic) of dispersants and chemically dispersed oil;
2. Rigorously evaluate each data source for their quality and potential for inclusion in the DTox database;
3. Compile all quantitative information including all relevant fields (e.g., species, exposure conditions, oil type and weathering, etc.);

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4. Integrate the above information into a tool that can be used by the end-user to guide management decisions regarding the use of dispersants; and
5. Test the suitability of the compiled quantitative data for use in spill response at two pilot study areas.

This effort focuses on aquatic fauna, primarily invertebrates and fish, including all life stages, and includes all pertinent information regarding experimental methods and settings including, oil and dispersant type, oil weathering stage, dispersant to oil ratios, and exposure duration, type (continuous vs. spiked) and concentrations (e.g., oil, PAHs or TPHs). Information from each study also includes analytical chemistry methods and the reported analyte(s). Each paper is carefully evaluated to ensure inclusion of good quality research.

A-3 Quality Assurance

Data included in DTox are evaluated following a strict set of rules aimed at selecting the best available and suitable data. Data entered into the database went through Quality Assurance and Quality Control (QA/QC) procedures including periodic reviews of the database to ensure accurate data entry. Specific QA/QC procedures are described below for each of the main objectives of this project.

Papers initially considered for inclusion in the database met the following minimum criteria:

- Articles published in English; except when information in another language could be accurately translated;
- Full scientific articles, numbered government reports, and independent consultant and industry reports (abstracts are not considered);
- Data should be from original scientific publications and peer review literature (primary source) rather than from reviews or unverifiable sources; a few exceptions are made, but data source penalized via applicability (see below)
- Species' common and/or scientific name, oil source, and dispersant type should be clearly stated;
- Biological test methods should be described, or reference made to an appropriate published method;
- Effects endpoints of treatment tests should be acceptable relative to control tests; studies that do not discuss or mention the use of controls where included on a case by case basis; and
- Methods for the chemical analysis used to quantify exposure concentrations associated with toxicological effects should be described or referenced.

The implementation of these selection criteria led to the exclusion of large amounts of information. Additional data are reconsidered for inclusion by relaxing the selection criterion, but potential data inaccuracies are noted within the database (see below for details). All papers and documents evaluated for potential inclusion in DTox are classified as follows:

- A1: Meets the selection criteria. A1 papers and documents are evaluated and included in the database;

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- A2: One or more of the selection criteria are questionable. A2 papers are be kept aside for further consideration and, if included in the database, potential data inaccuracies are be clearly noted;
- Rejected: Does not meet the selection criteria or does not contain data valuable to the goals of this project.

A-3.1 Data Compilation

Data entry followed a systematic, consistent, and accurate review process of the available literature. A carefully designed database template was developed, which included all the relevant database fields (data elements) and as many standardized data entries as possible (Table A-1). Data element definitions and descriptions are summarized in Table A-2. One of the fields within this template was created to enter the applicability of each paper (e.g., high, moderate, low). Applicability is judged based on source-specific considerations including. A brief summary of the criteria used in the assessment of applicability is as follows:

High:
- Papers reporting effects concentrations based on measured analytes (particularly those involving oil exposures)
- Dispersant to oil ratios consistent with typical recommended formulations
- Exposure conditions following existing recommendations for oil spill research

Moderate:
- Papers reporting effects concentrations based on measured analytes (particularly those involving oil exposures)
- Papers reporting effects concentrations for dispersant only exposures as nominal
- Dispersant to oil ratios consistent with typical recommended formulations
- Exposure conditions following standard toxicity testing laboratory practices

Low:
- Papers only reporting effects concentrations as nominal (particularly those involving oil exposures)
- Papers not clearly stating if the reported effects concentration are nominal or measured
- Papers with missing critical information (e.g., exposure conditions, analytical methods)
- Papers reporting only No Observed Effects Concentration (NOEC) or Lowest Observed Effects Concentration (LOEC)
- Papers with toxicity data from unverifiable sources

Note: Source applicability is assigned to individual papers and not to individual records. A paper reporting toxicity data based on oil loading rates (nominal exposures) also reporting effects concentrations based on measured analytes would have the same applicability assigned to each record entered in DTox. Also it is important to note that paper applicability is based on the relevance of its data to spill response, and not on the overall scientific merit of individual papers.

When entering data into the database template, the following rules are implemented:

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- To ensure completeness and accuracy, information is entered as not reported (NR) when information is not available, or not applicable (NA) when the field does not apply (e.g., toxicity testing with dispersant only has a NA dispersant to oil ratio);
- To ensure accuracy in data entry, all numbers between zero and one are reported with a preceding zero (e.g., 0.5 not .5);
- Periods are only used to represent a decimal points;
- Effects concentrations are entered as they appear in the original document (no rounding up or down is allowed);
- Drop down menus and standardized terminology are used for unique information (e.g., COREXIT 9500);
- Non-standardized data entry fields are entered exactly as they appear in the original source. Examples include: common name, scientific name, effects concentration, water temperature and complete citation; however, current scientific names are checked and replaced are needed, noting changes in reported versus final scientific names (see below);
- Units of numeric data are entered based on a standardized values (e.g., mg/L for effects concentrations, hours for exposure duration);
- Data sources with detailed data chemistry are noted within the database, and chemistry data entered into a separate form;
- Unique citations are assigned a numeric code that matches the citation's code of the bibliographic database (EndNote®); this unique numeric code provides the link between the data entered and the bibliographic citation; and
- A "Notes" field should include only relevant data not captured within other database fields.

Upon completion of data entry, global changes are applied to "new" data fields in the database. Examples include species (global) distribution, habitat, and water depth. Consideration was given to potential changes in habitat and water depth by species-specific life stages. Species distribution databases were consulted to accurately enter this information by species. Additionally, common and species names are checked, and global changes made including standardization of common names and assignment of official species names (e.g., *Mysidopsis bahia* changed throughout to *Americamysis bahia*). Any changes made to the original data source are clearly documented.

As part of the QA/QC components of this project, periodic reviews of the database are made to ensure accurate data entry. A minimum of 15% of all data sources are reviewed for accuracy and completeness. Critical steps of the QA/QC process includes the review of currently accepted scientific species names, standardization of column content and applicability criteria, and identification of duplicate data (e.g., several papers by the same author(s) reported in several report/manuscripts).

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Table A-1. List of standardized data entry fields. In all cases, not applicable (NA), not reported (NR) can be entered in the field cell. Non-standardized data entry fields include: effects concentration and complete citation. In brackets [], descriptive information related to a particular entry field. See Table A-2 for details.

Field Type	Field Name	Examples
Effects Database		
Species	Common name	Inland silverside
	Scientific name	*Menidia beryllina*
	Taxonomic group	Crustacean, fish, coral, mollusk, other[1]
	Life stage	Adult, juvenile, larvae, egg
	Species distribution	Tropical, subtropical, temperate, frigid, pandemic
	Species habitat[2]	Benthic, water column, epibenthic
	US standard test species	Yes, No
Experimental conditions and settings	Study type	Laboratory, field, mesocosm, wave tank
	Water type	Freshwater, seawater
	Dispersant/Oil Treatment	Dispersant only, Dispersant and Oil, Oil only
	Oil name	Alaska North Slope crude oil, South Louisiana crude oil
	API gravity	[Oil specific. Most data from NOAA's ADIOS (Automated Data Inquiry for Oil Spills)]
	Oil class (based on API gravity)	Light, Medium, Heavy, Extra-heavy
	Oil stage	Fresh, weathered, biodegraded
	Dispersant name	COREXIT9500, DISPERSIT, [including mechanical dispersion]
	Dispersant to oil ratio	1:10, 1:20
	Exposure conditions	Continuous, spiked, flow through, field
	Exposure duration (h)	24 hour, 96 hour
	Temperature (°C)	6 °C, 25 °C
Endpoints	Endpoint	Mortality, growth/development, behavior [grouped by endpoint type]
	Endpoint metric- Acute[3]	Acute: LC50, EC50, LOEC; Chronic: EC50, LOEC
	Qualifier	>, <, NA [these are qualifiers associated with the reported effects concentration]
	Effects concentration (mg/L)	200
	Effects concentration range	[Minimum|Maximum or Lower|Upper confidence interval of the reported effects concentration]
	Effects concentration analyte[4]	Total PAHs, TPHs, THCs
	Reported effects concentration	Measured, nominal
	Analyte endpoint	Initial, Final
	Analytical methods	Fluorometry, GC-MS
Data Source	Complete citation	Author, Year, Title, Journal/Agency
	Endnote Reference Locator	[value assigned to each citation entry in Endnote]
Other	Paper selection criteria	A1: Meets the selection criteria A2: One or more of the selection criteria are questionable Rejected
	Paper applicability	Low, Moderate, High, Rejected

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Field Type	Field Name	Examples
	Detailed analytical chemistry	Yes, No [if yes, data extracted and entered into chemical database]
	Duplicates	[It includes individual records identified as duplicates. Duplicates are not included in SSD calculations]
	Notes	[It includes any important information not captures in preceding fields]
Chemistry Database		
Analyte	General compounds	Total Petroleum Hydrocarbons, Polycyclic Aromatic Hydrocarbons
	Analyte name	n-Pentadecane (C15), Benzo(a)anthracene
	CAS#	50-32-8
Experimental conditions and settings	Dispersant/Oil Treatment	Dispersant only, Dispersant and Oil, Oil only
	Dispersant name	COREXIT9500, DISPERSIT, [including mechanical dispersion]
	Oil name	Alaska North Slope crude oil, South Louisiana crude oil
	Oil stage	Fresh, weathered, biodegraded
	Source type	Source oil, exposure media
	Concentration qualifier	>, <, NA
Analytical endpoint	Concentration (mg/L)	200
	Analytical methods	Fluorometry, GC-MS
Data Source	Complete citation	Author, Year, Title, Journal/Agency
	Endnote Reference Locator	[value assigned to each citation entry in Endnote]
Other	Notes	[It includes any important information not captured in preceding fields]

[1] Other include: bacteria (e.g., *Vibrio*), aquatic plants (e.g., giant kelp), phytoplankton, and echinoderms.
[2] Specific to the life stage of the tested species. For example, adult oysters would be categorized as inhabiting the epibenthos, while their larvae would be more likely found in the water column; [3] LC50: median lethal concentration, EC50: median effects concentration, NOEC: No Observed Effect Concentration, LOEC: Lowest Observed Effect Concentration;
[4] PAH: polycyclic aromatic hydrocarbons; TPH: total petroleum hydrocarbons; THC: total hydrocarbons content.

Table A-2. Key data element definitions.

Element Definition	Definition
Species common and scientific name	Refers to the species used in toxicity testing within each data source. Typically reported as common name and/or scientific name. Scientific names are checked against currently accepted names. Other information associated with species includes their taxonomic group, and the life stage used in toxicity testing. Both the global distribution of the tested species, and the habitat of the tested life stage are entered manually (typically not reported within data sources) based on information reported on global databases. Species are also assigned to whether these correspond to U.S. standard test species.
Water type	Refers to the nature of the water used in toxicity testing (freshwater or seawater).
Study type	Refers to the physical location where toxicity tests were conducted. It includes exposures under laboratory, field (e.g., outdoor uncontrolled conditions), mesocosm or wave tank conditions.
Dispersant/Oil Treatment	Refers to the type of aqueous exposure media used in toxicity

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Element Definition	Definition
	testing. It includes oil only (e.g., physically dispersed oil, or water accommodated fraction), dispersant and oil (e.g., chemically dispersed oil, or chemically enhanced water accommodated fraction), dispersant (e.g., dispersant in aqueous solution).
Oil name	Refers to the oil type (typically reported) used in toxicity testing within each data source. Other information associated with each oil entered into the database includes oil class categories (light, medium, heavy, extra-heavy) assigned based on API gravity (most information from NOAA/ADIOS).
Oil condition	Refers to the nature of the oil used to derive the exposure media. It includes fresh, weathered (naturally or artificially) or biodegraded oil.
Dispersant name	Refers to the dispersant product (typically reported) used in toxicity testing within each data source. Entered as reported, typically commercial name. Other information associated with each dispersant, if used in combination with oil, includes the dispersant to oil ratio (DOR) used to prepare the aqueous exposure media.
Exposure conditions and other related exposure information	Refers to the type of experimental design used to conduct toxicity testing. Examples include: Constant static (with or without open vessels) – Refers to toxicity tests performed in the absence of low. Aqueous exposure media typically remains unchanged throughout the duration of the test. Static or semi-static renewal– Refers to the a test without continuous flow of solution, but with renewal of aqueous exposure media Flow through test– Refers to the continuous or very frequent passage of aqueous exposure media through a test chamber with no recycling. Spiked, pulsed, and spiked, flow-through (with or without open vessels) – Refers to initial spike in concentrations in the exposure media, which is allowed to decline over the duration of the exposure period. Other information associated with the exposure conditions include exposure duration and water temperature (not always reported).
Endpoints and other related endpoint information	Endpoint refers to the biological metric used to characterize toxicity. For the purpose of this database, endpoints are grouped by– Mortality (primarily LC50 data); Growth and Development (e.g., blue sac disease, embryo abnormalities) (primarily EC50 data); Reproduction (e.g., fecundity, fertilization inhibition, percent Hatch) (primarily EC50 data); Biochemical (e.g., CYP1A induction, EROD activity) (primarily EC50 data); Physiology (e.g., Heart rate, Impaired byssal activity, Impaired shell-closure) (primarily EC50 data); and Behavior (e.g., feeding rate, impaired swimming) (primarily EC50 data). Endpoints include: LC50 – Median lethal concentration that kills 50% of the exposed organisms at a specific time interval; EC50 – Median effects concentration that causes an response in 50% of the exposed organisms at a specific time interval;

Element Definition	Definition
	LOEC (Lowest Observed Effect Concentration)– The lowest concentration that causes a response statistically different from the control; and NOEC (No Observed Effect Concentration)– The highest concentration that causes a response statistically different from the control. Whenever available information is also included on control Endpoints– How test treatments compared to controls.
Effects Concentration and other related information	Effects Concentrations (mg/L) refer to the mean reported value. Note: All concentration information is standardized to a single consistent concentration unit (mg/L). Whenever reported, the database also includes: Minimum or lower confidence interval of the effects concentrations (mg/L)– Either the minimum or the lower confidence interval of the reported value; and Maximum or upper confidence interval of the effects Concentrations (mg/L) – Either the maximum or the upper confidence interval of the reported value. Information is also included on whether or not the effects concentrations were derived from measured or nominal concentrations of the exposure media. Analytes include: total polycyclic aromatic hydrocarbons (PAHs), total hydrocarbon content (THC), among other analyte types. If available, information is also entered on the analytical method used to characterize the exposure media: Fluorometry, GC-MS
Data Source	Refers to the source from which toxicity data are obtained. It includes a complete citation (author, year, title, journal/agency)

A-3.2 Tool Development

Data were initially entered into a spreadsheet and later migrated into a database program (FileMaker® Pro 12) with expanded capabilities. The database contains multiple data formats, including graphs and relational tables that reflect the nature of the data, and is flexible enough to allow incorporation of ongoing and future studies. The format and structure of this interactive database has the characteristics of a sister database CAFÉ (Chemical Aquatic Fate and Effects Database, NOAA/ERD), allowing current CAFÉ users to query data in DTox without additional training. A similar data structure also allows for potential integration of DTox with CAFÉ.

Integration of the data template into FileMaker® Pro 12 required the following, in operational order:

- Set field requirements to identify data errors during and after data import into FileMaker® Pro 12;
- Establish data check routines to identify legitimate and illegal field combinations (e.g., oil exposures only should not have a dispersant name), check for blank cells that should have either numeric or text entries, ensure that tables (e.g., DTox and chemistry table) are properly linked based on a common numeric code link (e.g., unique EndNote® citation number);
- Verify that 100% of the data fields have converged into FileMaker® Pro 12

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- Design tools and reports that address the needs of end-users with disabilities (e.g., color blind) (Section 508 29 U.S.C. '749d) by selecting colors suggestions for color blind, as well as font size and style options;
- Run tests and other assessment procedures on the user interface tool, data queries and database products (reports, graphs) to make sure these meet the goals of the database. These test involved the selection of a variety of likely end-user scenarios (e.g., queries with few to several end-user requirement specifications);
- Additional tests aimed at improving system performance, response time, and vulnerability;
- Perform an internal review of an alpha version of the database within project team, including potential RPI end-users and members of CAFÉ's development team;
- This phase of the QA/QC plan also included detailed documentation of decisions and procedures (e.g., data entry, tracking and manipulation), as well documentation of assumptions, theory, and parameterization used in developing Species Sensitivity Distribution curves (SSDs) (see below); and
- As part of the QA plan, computer file back-up procedures were regularly undertaken.

A beta version of the interactive database was designed and tested internally and externally for input and suggestions on improvement, prior to its dissemination among selected end-users. This process allowed the project team to address and improve the tool prior to its public release.

Key attributes of this database include:

- Easy to follow layout;
- Query screens to allow for user-specific data inclusion/exclusion;
- Interactive standard navigation buttons containing the most common search attributes;
- Search results displayed in tables and graphics;
- Appearance and functionality;
- A "How To" document detailing how to perform data queries, and a copy of the most recent QA/QC Plan; and
- A copy of the EndNote® library containing the complete list of citations of all papers reviewed as part of this project.

A-3.2.1 Data Queries and Species Sensitivity Distributions

The first version of DTox contains several navigation windows allowing data selection by the end-user. Following data selection, the remaining data are plotted in separate windows in the form of Species Sensitivity Distributions (SSDs). SSDs are constructed by calculating the geometric mean of reported toxicity for each individual species (by scientific name). Data included in geometric mean calculations are:

- Data with effects concentrations qualifiers equal to NA
- Effects concentrations with qualifiers ≥, ≤, > or < are not included in calculations
- Data identified as duplicates are not included in calculations
- Data from Rejected papers are not included in calculations

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- SSDs are only generated for datasets with a minimum of 5 species

Additional details on SSDs include:

- SSDs are generated by fitting the empirical toxicity data to a logistic function defined by $F(x) = \frac{1}{1 + e^{-\frac{x-\mu}{\sigma}}}$, $x \in R$, with parameters μ(location) and σ (scale);
- Fitted SSDs do not include a "Goodness of Fit" test;
- Two Hazard concentrations (HC) (HC1 and HC5 equivalent to the concentrations at which 1% and 5%, respectively, of the species in the SSD may not be protected) are included for plots with a minimum of 5 species;
- Up to two SSDs are plotted per display window (Dispersant Only, Dispersant and Oil, Oil Only);
- 1 SSD per display window includes common names;
- 2 SSDs per display window omits common names;
- Data are displayed based on color coding selections; and
- All SSDs are plotted over a colored background representing a common scale of relative toxicity.

Scale
Very highly toxic (<0.1 mg/L)
Highly toxic (0.1-1 mg/L)
Moderately toxic (1-10 mg/L)
Slightly toxic (10-100 mg/L)
Not acutely toxic (>100 mg/L)

A-3.2.2 Tool Testing and Distribution

A stand-alone executable file (beta version) of the interactive database was further tested internally, and shared with external potential users and volunteers for input and suggestions on improvement, prior to its dissemination among selected end-users. This process allowed the project team to address and improve the tool prior to its public release. A stand-alone executable file of the first version of DTox was made available and shared with a selected number of end-users. End-users were asked to provide feedback and to report issues, which will be considered in future updates of the tool.

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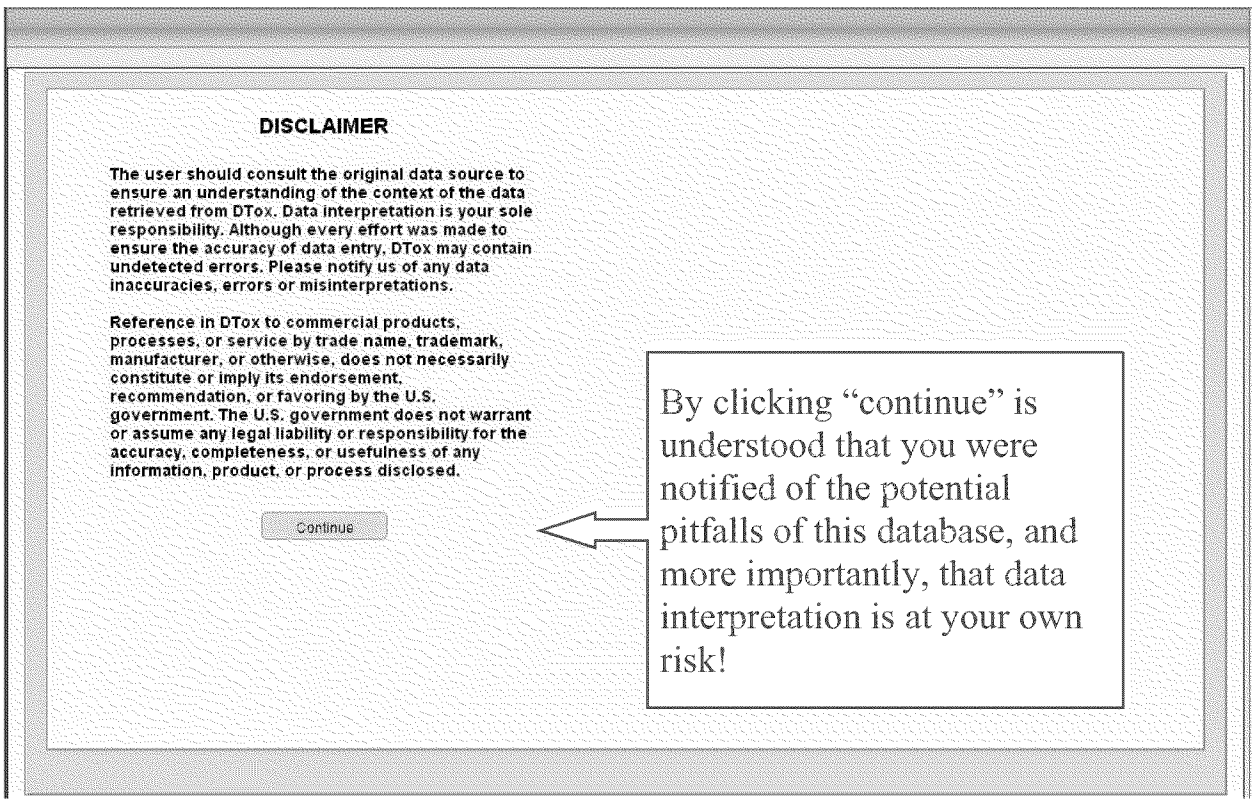
Appendix B- HOW TO "DTox" Version 1.

This document provides a brief overview on how to navigate through DTox. Before you start querying DTox, please read through the information presented here as it is intended to facilitate the use of this tool.

Performing queries in DTox-

Below you will find a series of screens shots through which you would have to navigate to perform the desired queries

1. **Disclaimer**



2. **Data selection**

There are several windows allowing the selection of the type of data you want included in your query. **Note** that if selections are not made, by default, the program will select all the available data.

   a. **Species**

Note that while only common names are listed, these correspond to "unique" scientific names.

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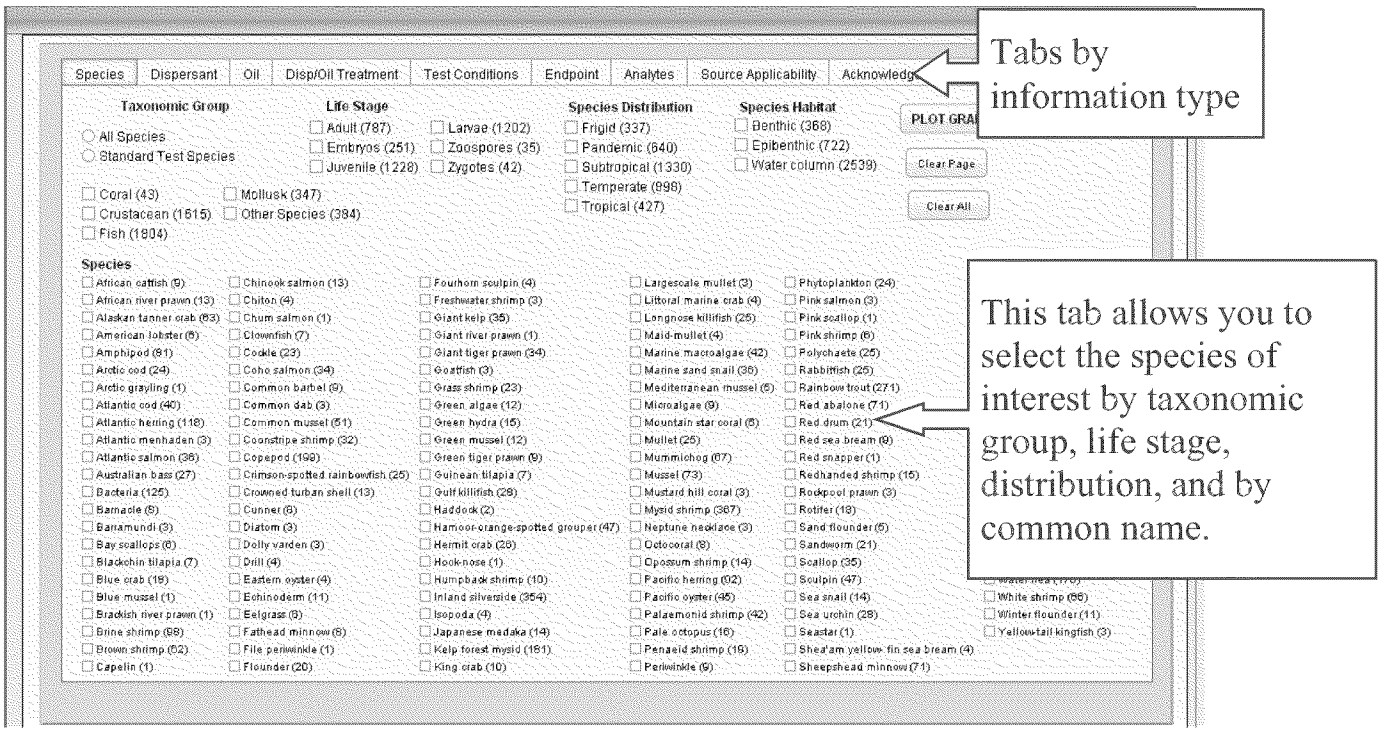
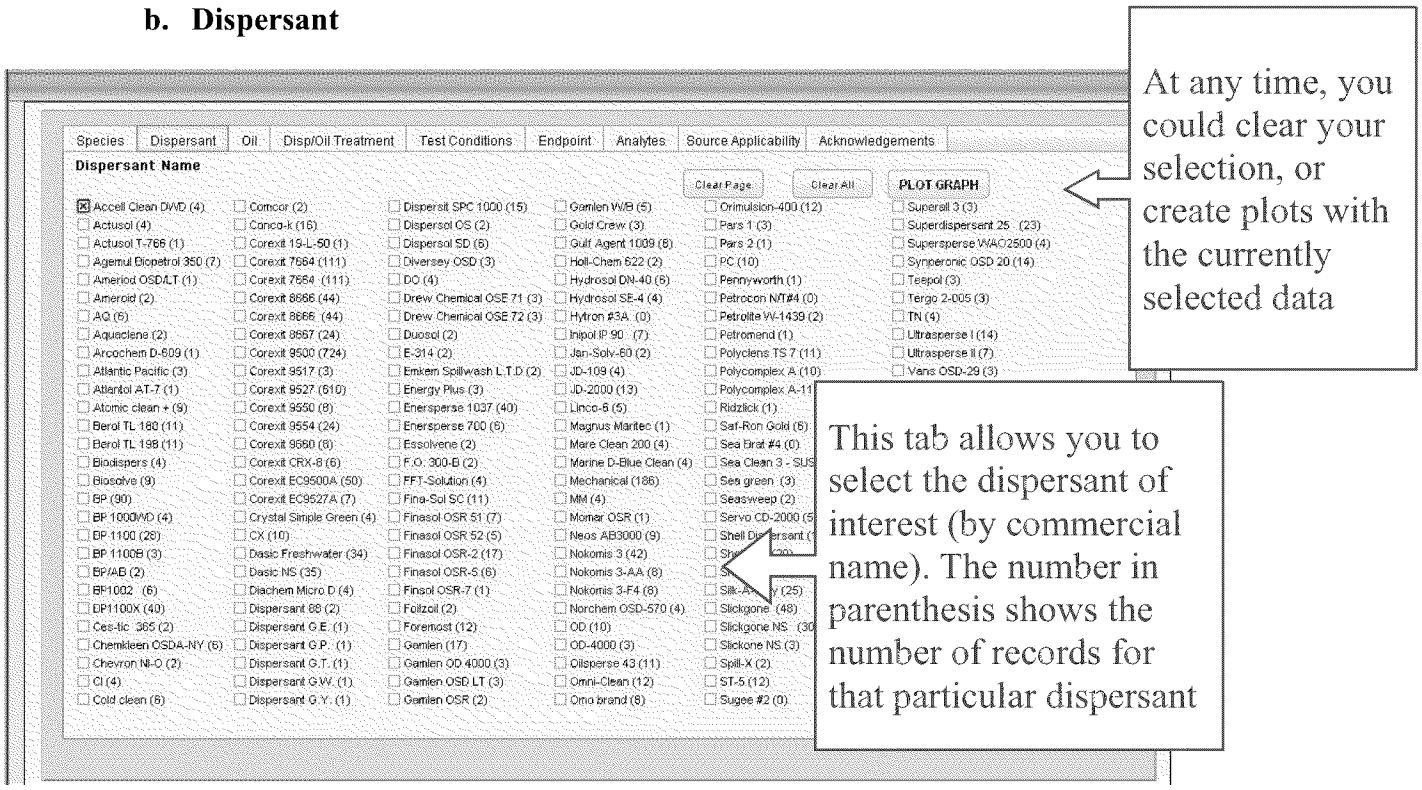
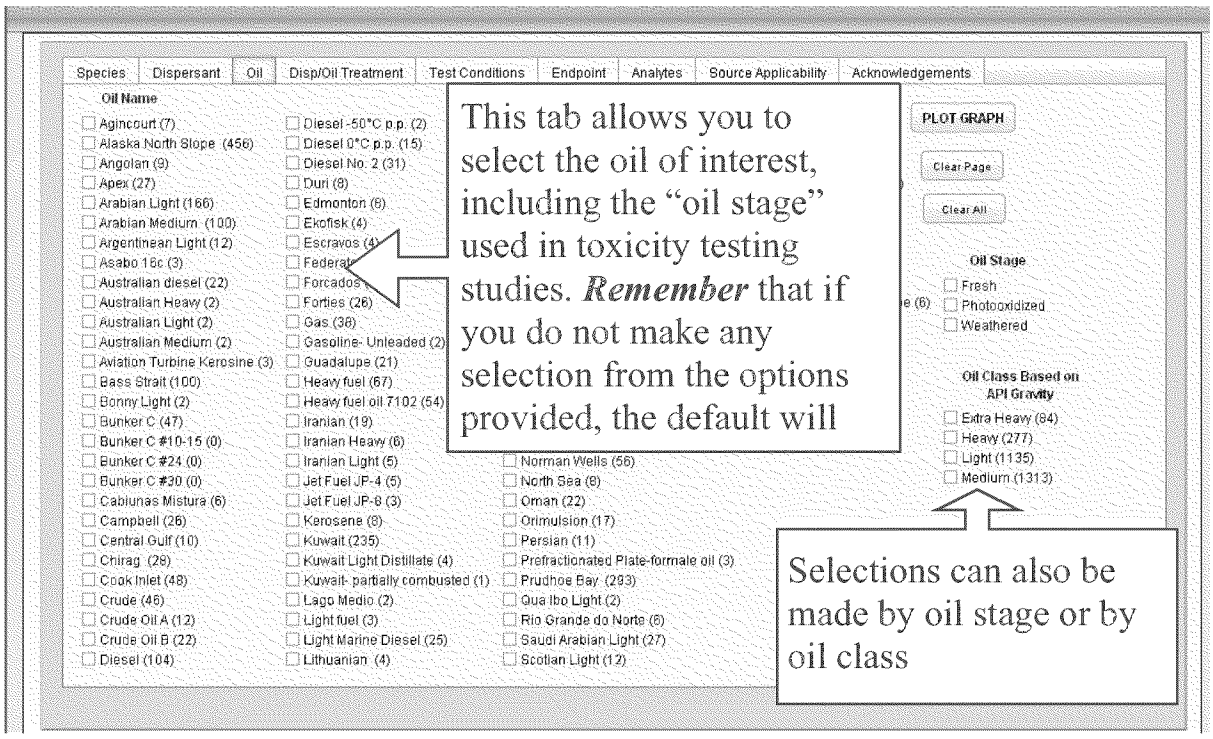


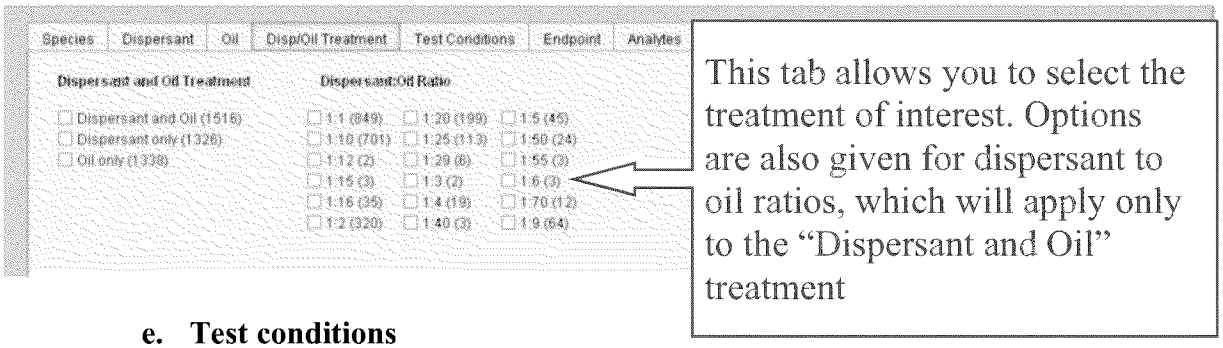
b. Dispersant



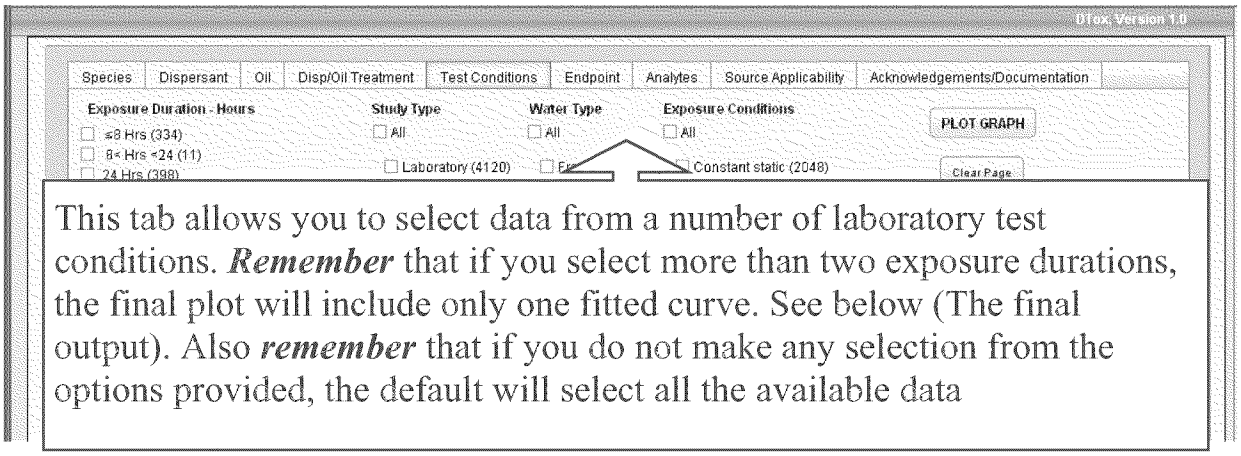
c. Oil



d. Dispersant/oil treatment

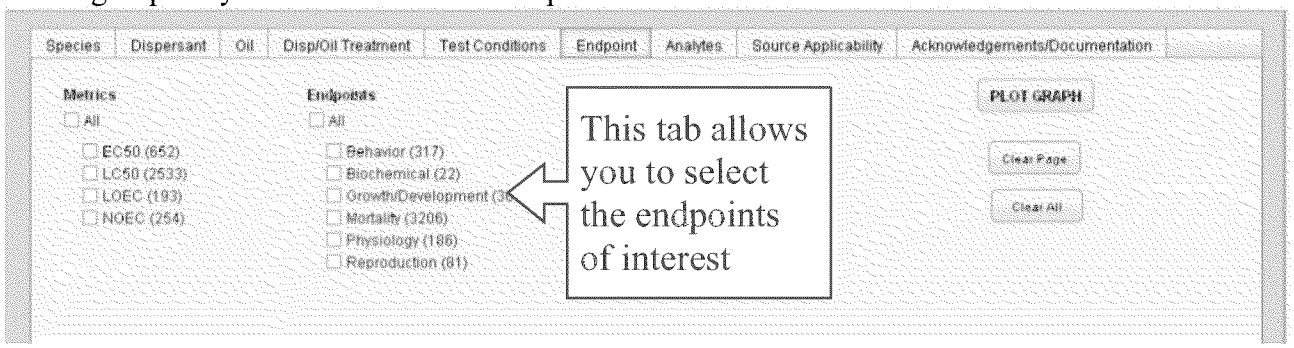


e. Test conditions

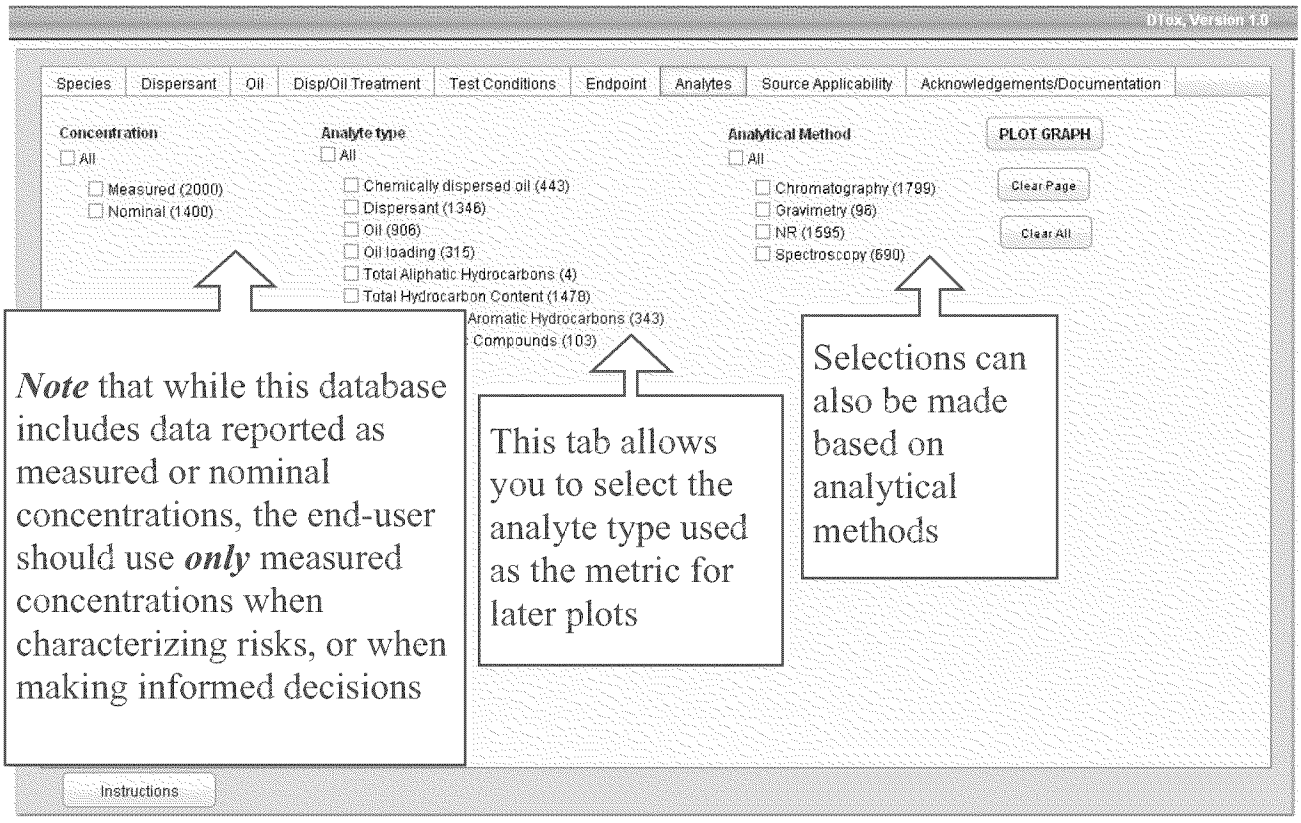


f. Endpoints

Toxicity metrics included in DTox include the most commonly reported types, grouped by lethal and sublethal endpoints.



g. Analytes



h. Source applicability

A detailed Quality Assurance/Quality Control plan was written prior to the development of this tool. A brief summary of the criteria used in the assessment of applicability[2] is shown below:

High:

[2] "Applicability" is meant to indicate the applicability or usability of these data to spill response, and to the specific goals of this project. Assigning "applicability" to each data source is not to be interpreted as a judgment of the scientific quality of each data source.

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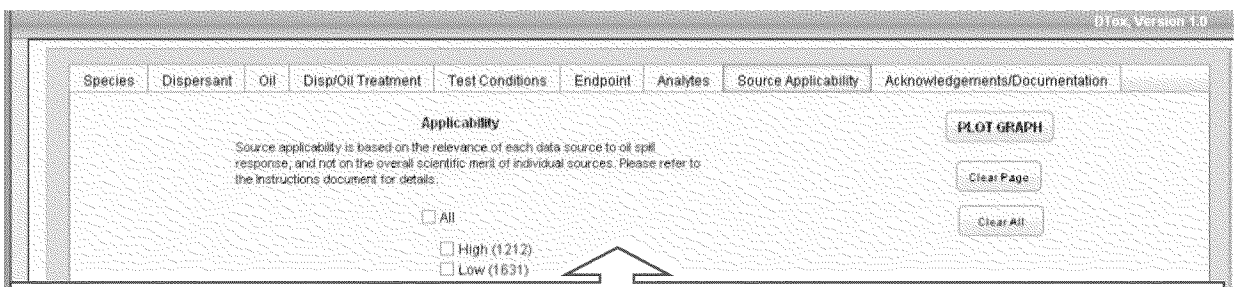
- Papers reporting effects concentrations based on measured analytes (particularly those involving oil exposures)
- Dispersant to oil ratios consistent with typical recommended formulations
- Exposure conditions following existing recommendations for oil spill research

Moderate:
- Papers reporting effects concentrations based on measured analytes (particularly those involving oil exposures)
- Papers reporting effects concentrations for dispersant only exposures as nominal
- Dispersant to oil ratios consistent with typical recommended formulations
- Exposure conditions following standard toxicity testing laboratory practices

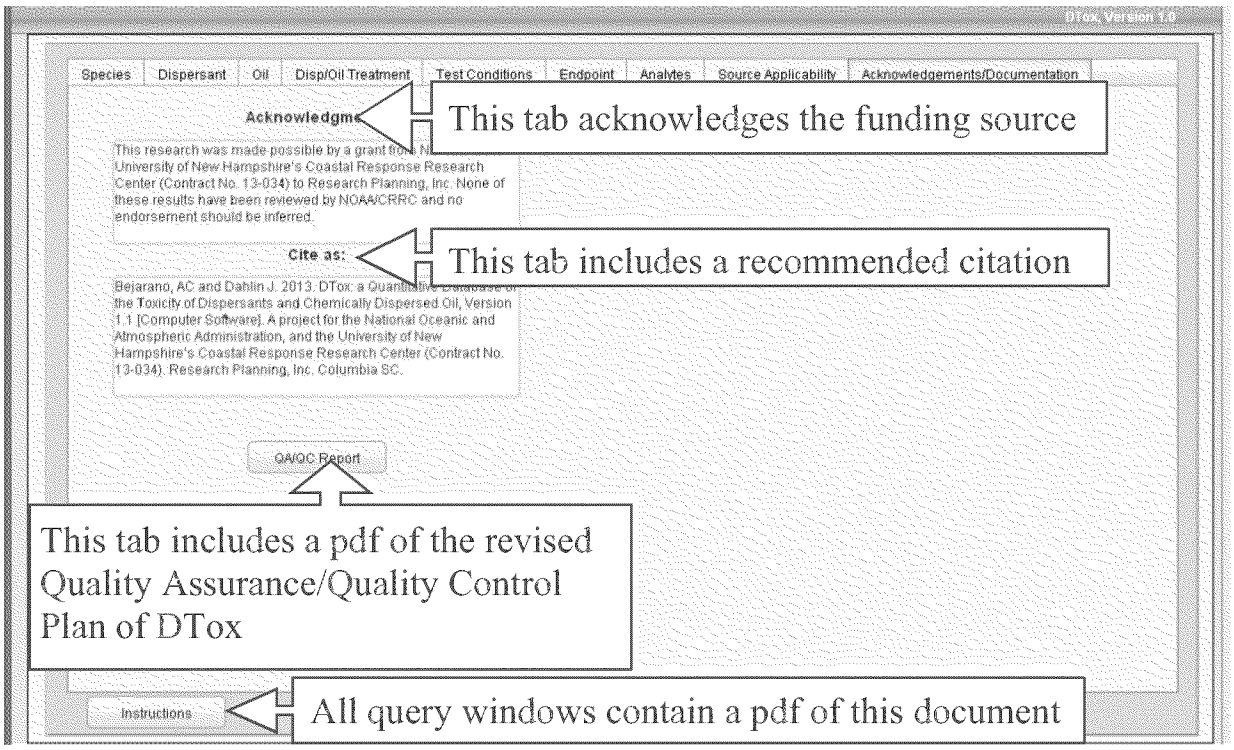
Low:
- Papers only reporting effects concentrations as nominal (particularly those involving oil exposures)
- Papers not clearly stating if the reported effects concentration were nominal or measured
- Papers with missing critical information (e.g., exposure conditions, analytical methods)
- Papers reporting only NOEC, LOEC effects concentrations
- Papers with toxicity data from unverifiable sources

Note: Source applicability is assigned to individual papers and not to individual records. A paper reporting toxicity data based on oil loading rates (nominal exposures) also reporting effects concentrations based on measured analytes would have the same reliability assigned to each record entered in DTox.



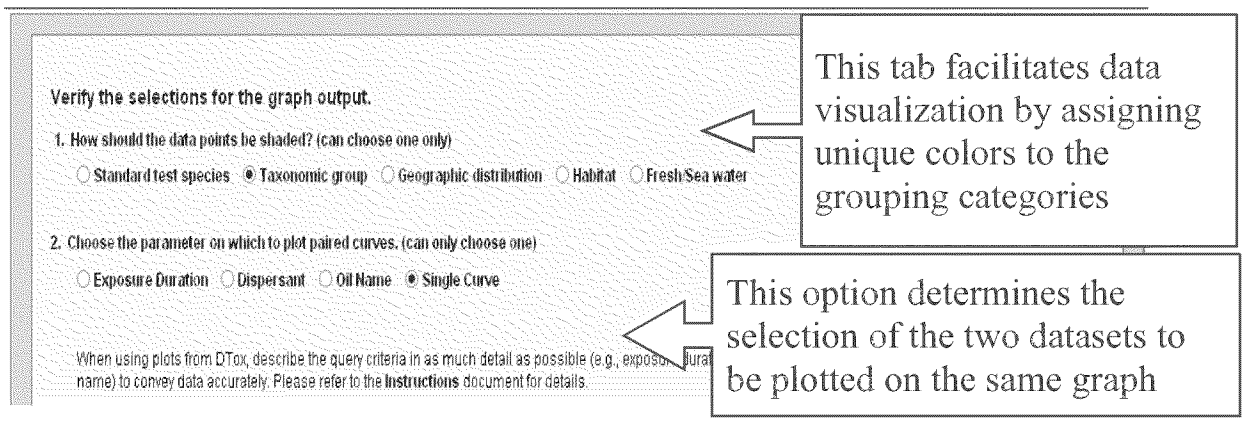
Each data source in the DTox was given an applicability score, based on the scientific value of these data to spill response. The end-user is encouraged to use the two higher applicable sources (Moderate/High) when characterizing risks or when making informed decisions

i. Acknowledgements and Documentation



3. Data plotting options

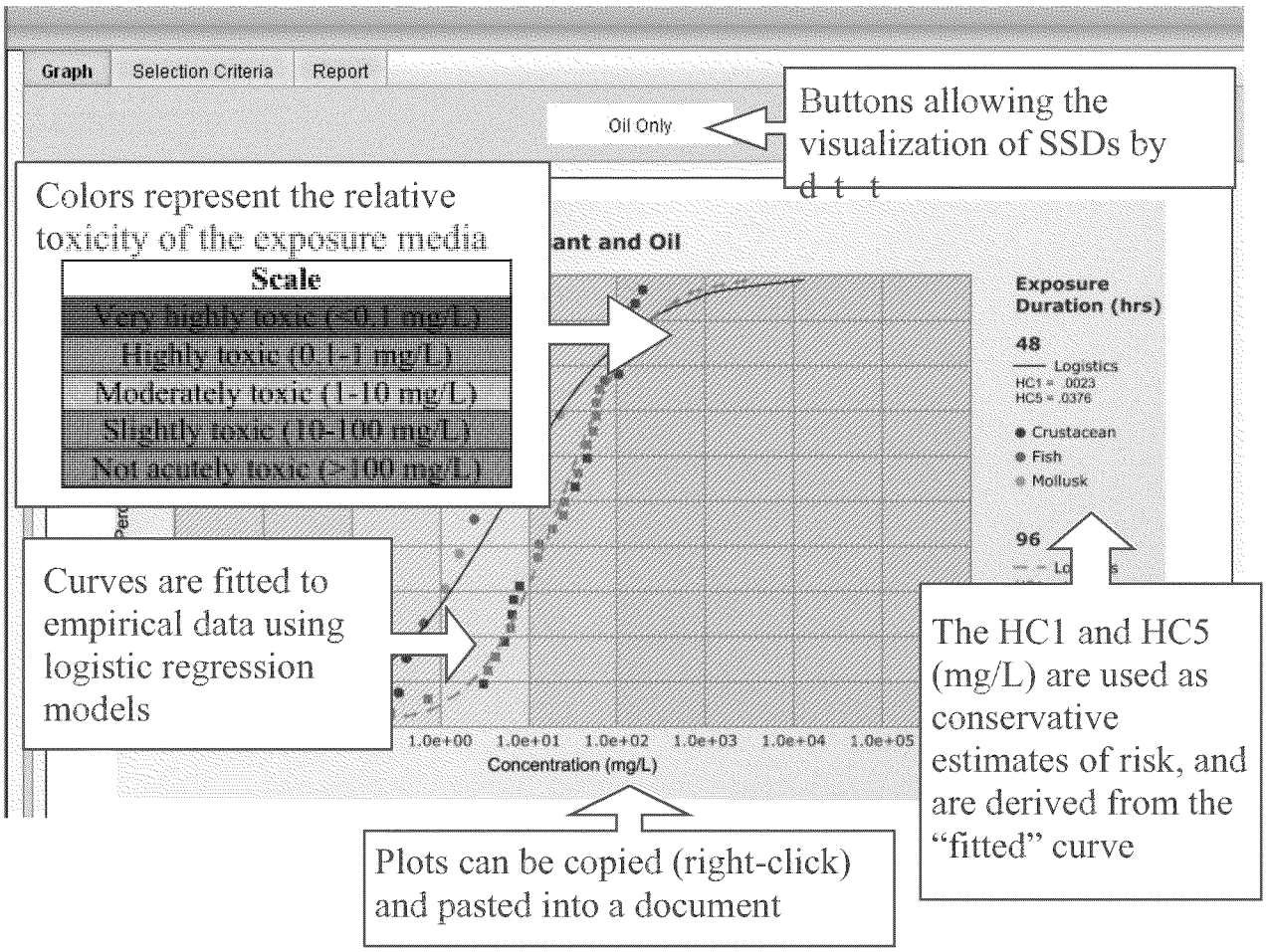
Once you have gone through the data selection tabs, your will get to chose how you want your data plotted. **Note** that only two curves can be plotted simultaneously on the same window. If more than three options are selected, only two will be plotted. For example, under exposure duration select two (e.g., 24 h and 96 h). Press "Plot Graph" to see the plotted output. This may take a few seconds… Following the step above, you will see the internal query being performed. You may need to wait a few seconds while the plots are generated.

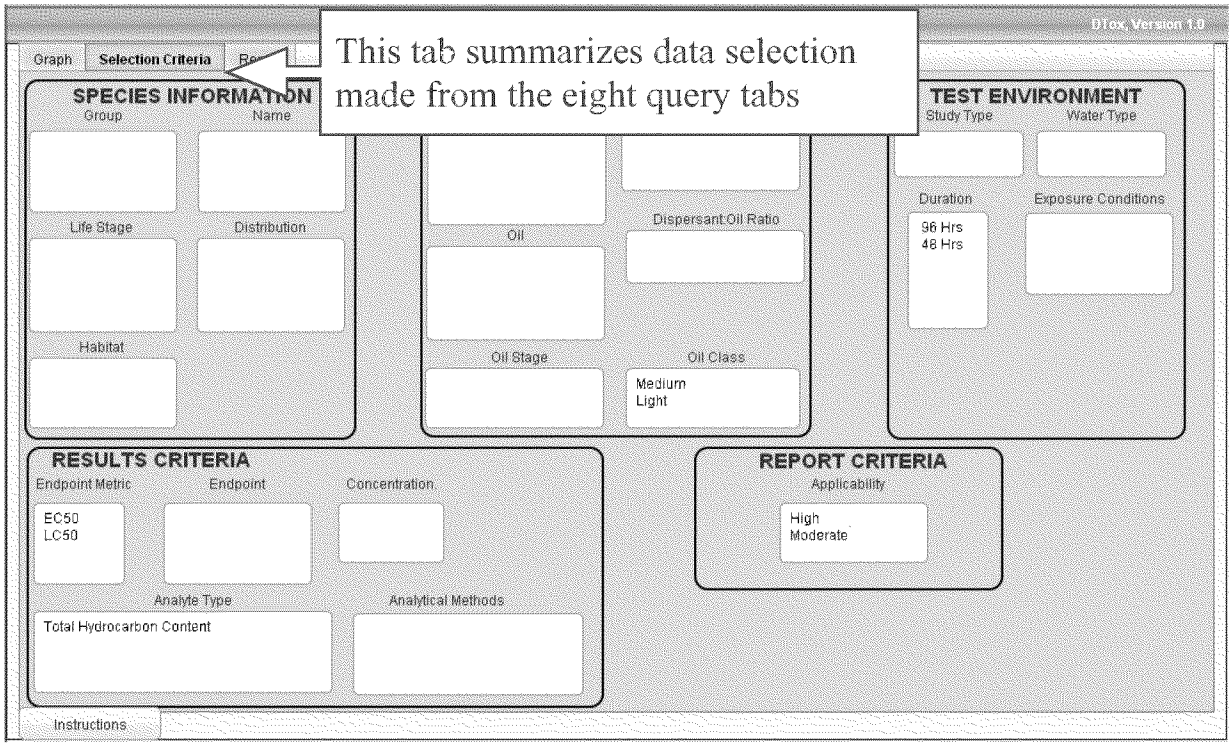


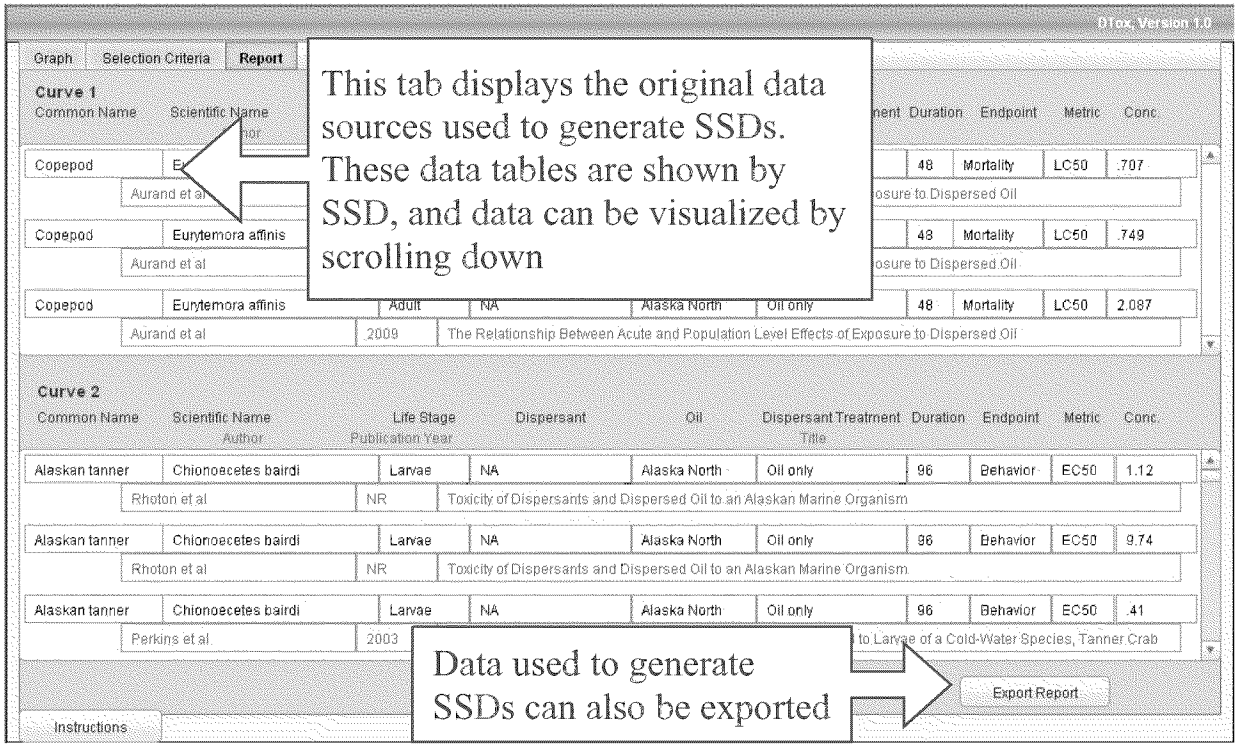
4. The final output

Queried data are combined to generate Species Sensitivity Distributions (SSDs). SSDs describe the sensitivity of aquatic species to the exposure media, where each point on the curve represents the geometric mean of all toxicity data available for a uniquely identified species (e.g.,

calculated by scientific name). SSDs are generated by ranking the relative sensitivity of individual from the least to the most sensitive, and are useful in that benchmark concentrations (hazardous concentration, HC) can be derived as a measure of risk. Here the 1st and 5th percentiles of the SSD (HC1 and HC5, respectively; in mg/L) are used as benchmark concentrations under the assumption that these would be protective of 99% and 95%, respectively, of the species on the SSD.




DTox Version 1.0
Graph
Selection Criteria
This tab summarizes data selection made from the eight query tabs
SPECIES INFORMATION
Group
Name
Life Stage
Distribution
Habitat
Oil
Dispersant:Oil Ratio
Oil Stage
Oil Class
Medium
Light
TEST ENVIRONMENT
Study Type
Water Type
Duration
Exposure Conditions
96 Hrs
48 Hrs
RESULTS CRITERIA
Endpoint Metric
Endpoint
Concentration
EC50
LC50
Analyte Type
Analytical Methods
Total Hydrocarbon Content
REPORT CRITERIA
Applicability
High
Moderate
Instructions


DTox Version 1.0
Graph
Selection Criteria
Report
This tab displays the original data sources used to generate SSDs. These data tables are shown by SSD, and data can be visualized by scrolling down
Curve 1
Common Name
Scientific Name
Duration
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Conc
Copepod
Aurand et al
48
Mortality
LC50
.707
Copepod
Eurytemora affinis
48
Mortality
LC50
.749
Copepod
Eurytemora affinis
Adult
NA
Alaska North
Oil only
48
Mortality
LC50
2.087
Aurand et al
2009
The Relationship Between Acute and Population Level Effects of Exposure to Dispersed Oil
Curve 2
Common Name
Scientific Name
Author
Life Stage
Publication Year
Dispersant
Oil
Dispersant Treatment
Title
Duration
Endpoint
Metric
Conc
Alaskan tanner
Chionoecetes bairdi
Larvae
NA
Alaska North
Oil only
96
Behavior
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Rhoton et al
NR
Toxicity of Dispersants and Dispersed Oil to an Alaskan Marine Organism
Alaskan tanner
Chionoecetes bairdi
Larvae
NA
Alaska North
Oil only
96
Behavior
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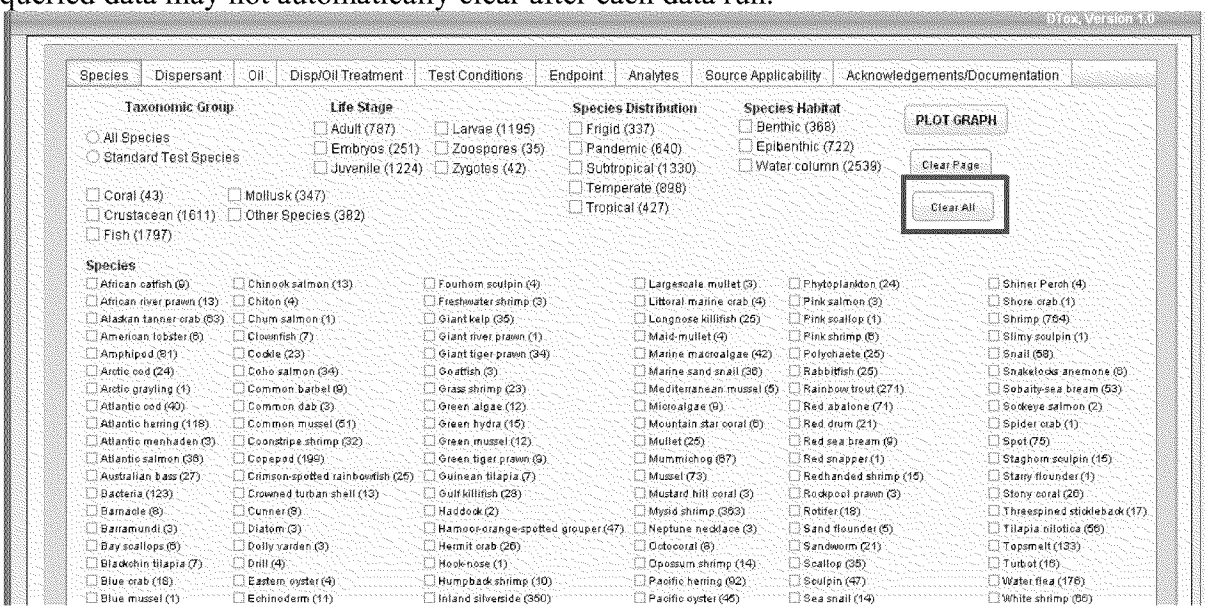
9.74
Rhoton et al
NR
Toxicity of Dispersants and Dispersed Oil to an Alaskan Marine Organism
Alaskan tanner
Chionoecetes bairdi
Larvae
NA
Alaska North
Oil only
96
Behavior
EC50
.41
Perkins et al
2003
Data used to generate SSDs can also be exported
Export Report
Instructions

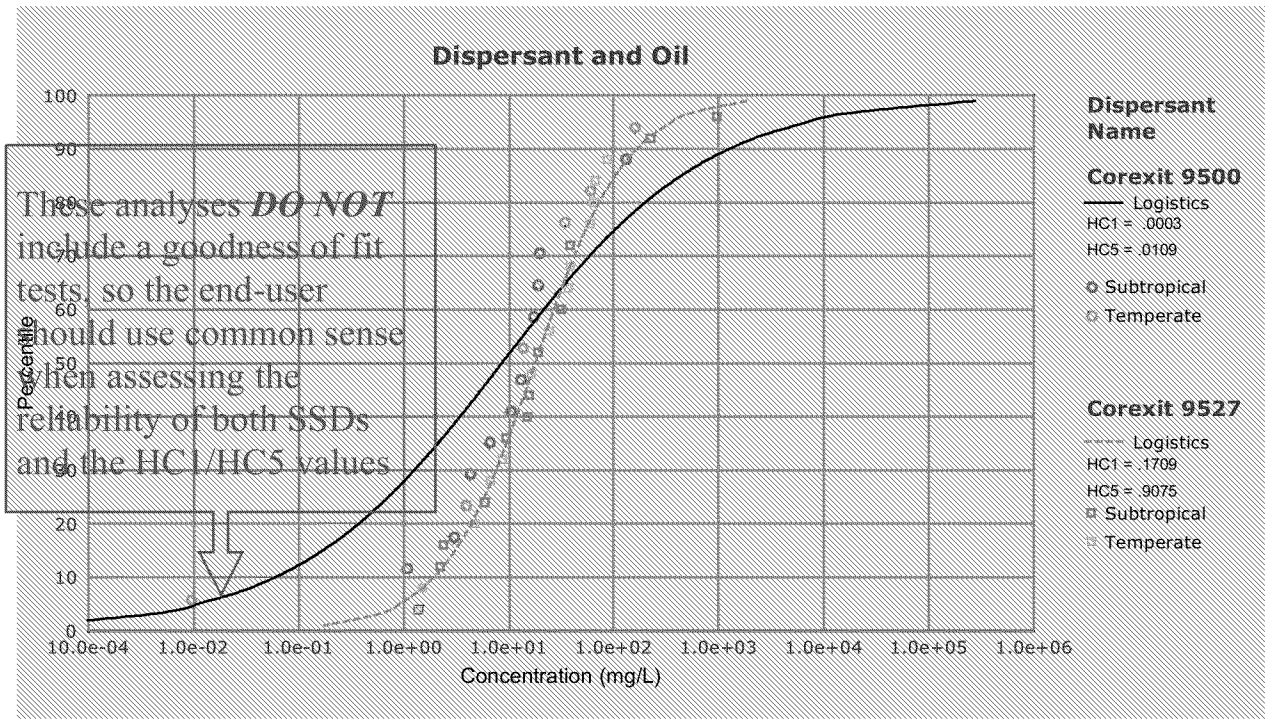
Note 1:

To ensure optimal performance and query replicability, press "clear all" after each query run. This is highly recommended step when performing multiple queries as the table containing the queried data may not automatically clear after each data run.



Note 2:

A note of caution…



Zip File Bonus!.

The zip file containing the executable file of DTox also includes the EndNote® library, with all the references evaluated during the development of this tool

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Recover.log			
DTOX.fmpur			
DTox_COMPRESSED.enl			
DTox_COMPRESSED.enlx			
zlib1.dll			
XText.dll			
XGrfx.dll			
XFC.dll			
xerces-c_3_0.dll	1,839 KB	Application Extension	3/21/2013 1:47 PM
XDraw.dll	526 KB	Application Extension	3/21/2013 1:47 PM
XCore.dll	91 KB	Application Extension	3/21/2013 1:47 PM
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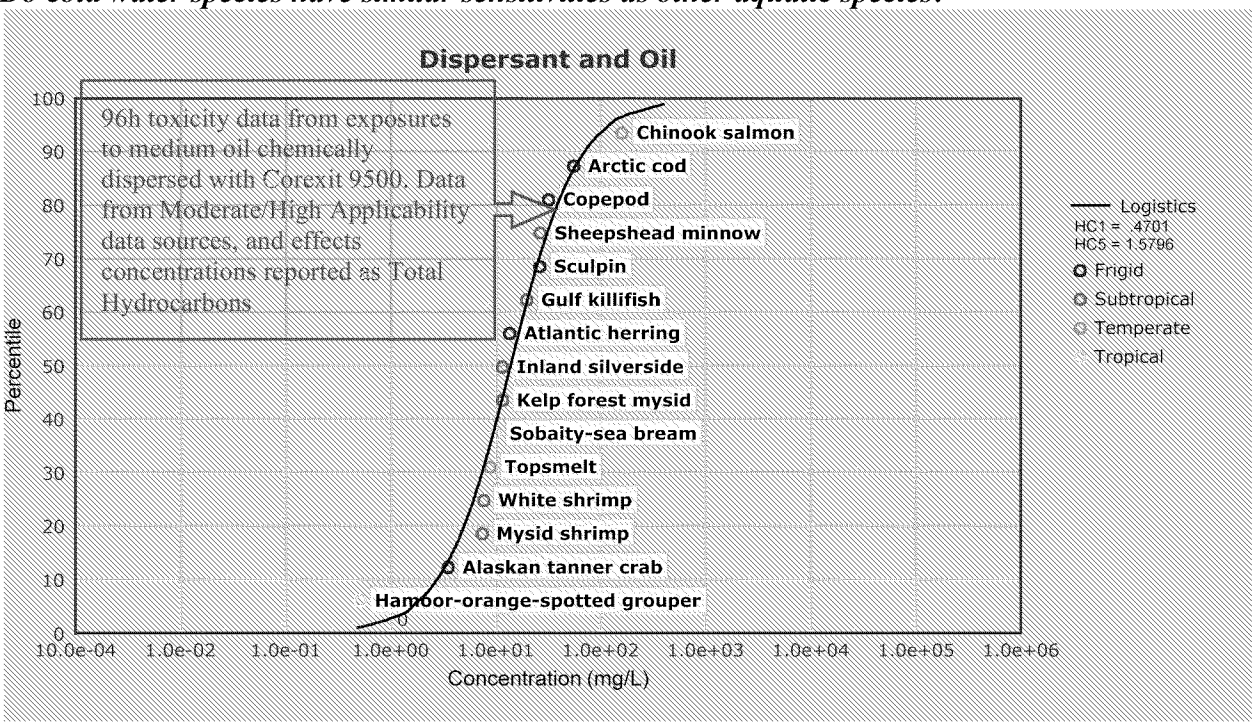
FMEngine.dll	4,391 KB	Application Extension	3/21/2013 1:47 PM
DBEngine.dll			
DTox.exe			
HowTo_DTox.pdf			

Pdfs of this document and the QA/QC plan are also in the DTox folder

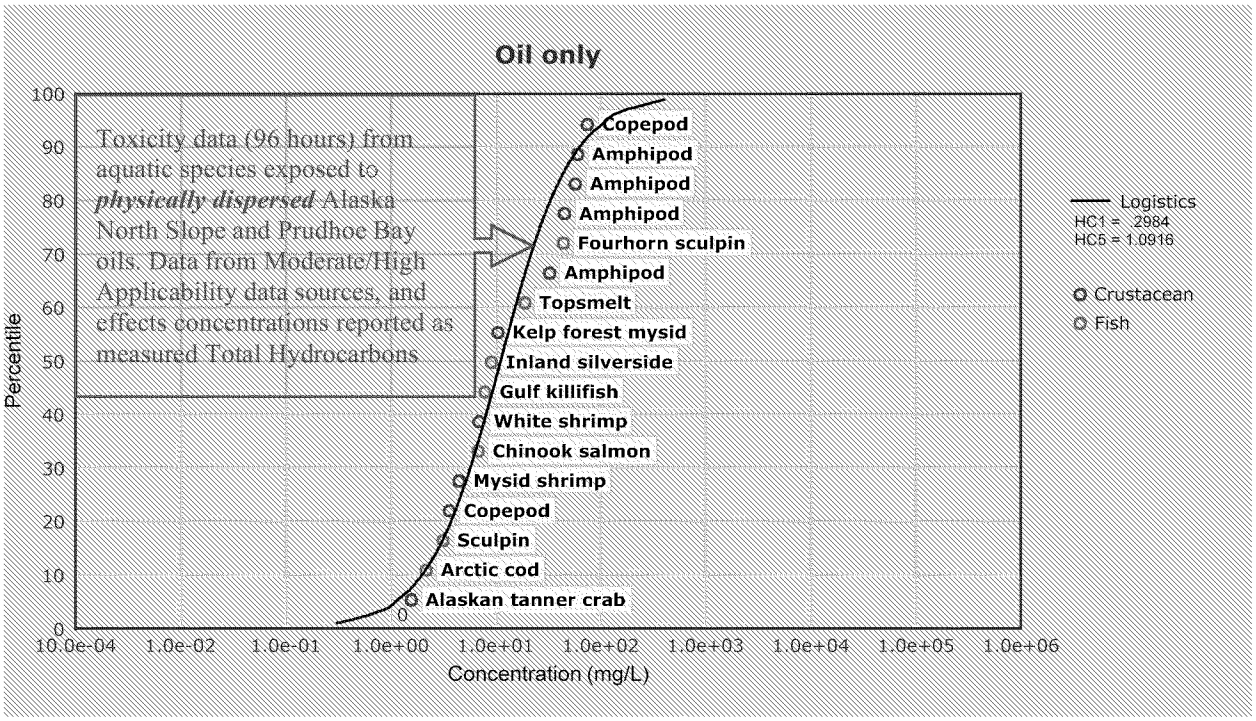
How to use outputs from DTox:
Data in DTox has several practical applications, including their use to address and answer basic questions:

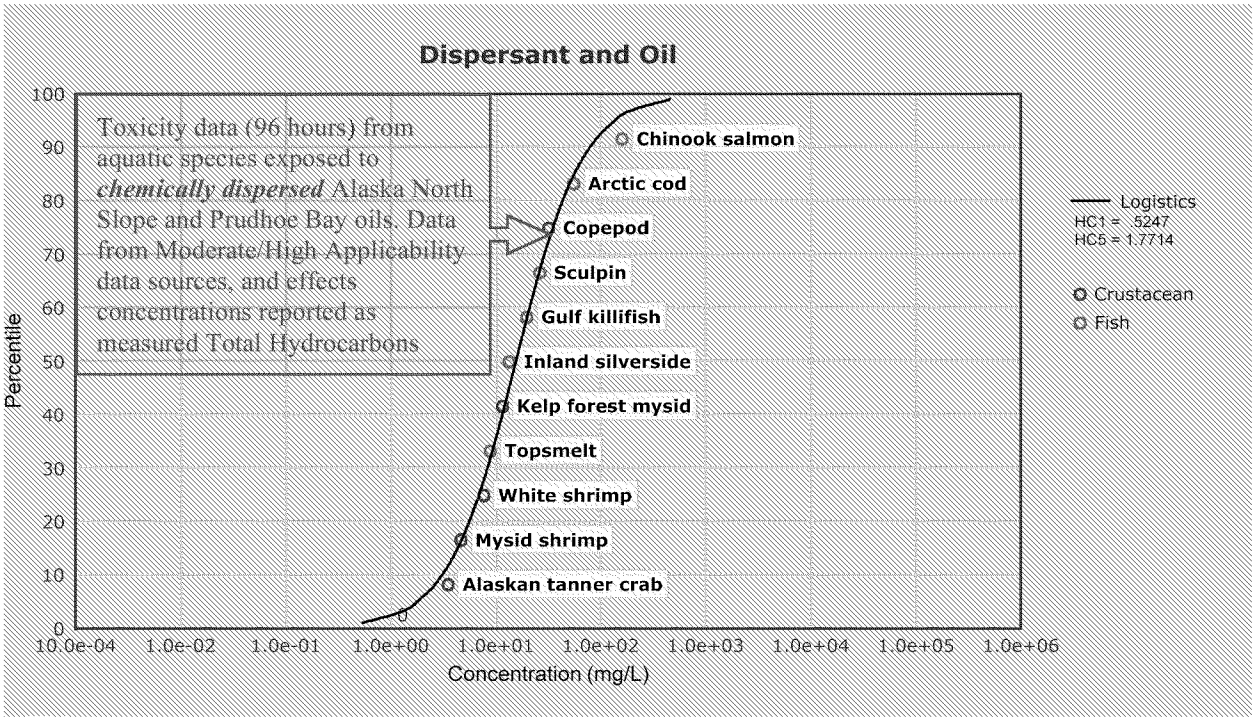
Do cold water species have similar sensitivities as other aquatic species?



Answer: Yes. Cold water species have similar sensitivities to medium oil chemically dispersed with Corexit9500 as temperate species (top plot), as well as one of the U.S. standard test species (topsmelt) (bottom plot). Therefore, both temperate and U.S. standard test species may be suitable surrogate for cold water species in toxicity testing of oil and dispersants.

Does Corexit 9500 increase the toxicity of Alaskan oils?





Answer: No. Based on the best available toxicity data available to date, there is no evidence that Corexit9500 increases the toxicity of Alaskan oils. As shown above, curves from physically and chemically dispersed oil are similar and both have comparable hazard concentrations (HCs).

ED_001324_00008405-00065

To: Craig Matthiessen[Matthiessen.Craig@epa.gov]
Cc: Principe, Vanessa[principe.vanessa@epa.gov]
From: Wilson, Gregory
Sent: Thur 7/30/2015 6:29:59 PM
Subject: FW: SMART confusion
Steve Lehmann email attachment 8/24/2012
C. Matthiessen email – 8/3/2012
Steve Lehmann email – 8/7/2012
FW: SMART - TTP - IPT Stage 3 Coord Draft Meeting @ 1400/2:00pm EST / 1100-PST
ICCOPR R&T Plan Chapters 7 , 8, and 9 for review
NOAA Subpart J Comments

Craig -

After reviewing several documents on dispersant monitoring, I wanted to put together a "quick" note on some observations to share with you. After DWH, the NRT tasked two committees, the Preparedness and Science and Technology committees to develop a subsea and dispersant use guidance documents, respectively. USCG (Bob Pond) led the subsea dispersant guidance document under the Preparedness committee while Steve Lehmann (NOAA) led the surface dispersant effort. In addition to Bob Pond, Ed Levine (NOAA), David Bahler (DOI) and myself participated in drafting the subsea document. Later, the two efforts were combined under one committee led by Steve Lehmann that eventually became the Environmental Monitoring for Atypical Dispersant Operations document.

The NRT's Environmental Monitoring for Atypical Dispersant Operations document focuses on 1) subsea application guidance and 2) prolonged surface application guidance. As described in the document, "atypical" dispersant use applies to subsea dispersant application, and surface dispersant application on discharged oil extends beyond 96 hours from the time of the first application. The NRT Atypical guidance document distinguishes between surface dispersant applications covered by SMART and prolonged surface dispersant application (i.e., surface dispersant application on discharged oil extends beyond 96 hours from the time of the first application.) No such time distinction is provided for subsea dispersant use. The document notes that: "Such atypical uses of dispersant during a response were neither envisioned nor incorporated into existing Regional Response Team (RRT) dispersant use plans, nor were they addressed in the existing Special Monitoring of Applied Response Technologies (SMART) monitoring program." (page 4)

During the development of the document the issue of using dispersant to control VOCs emerged. Earlier draft versions of the NRT guidance document included a section that focused on monitoring (see attachment to C. Matthiessen email – 8/3/2012). Later versions stated that VOCs should be measured in the vicinity of fresh oil as a function of the site safety plan for the

purpose of overall worker protection. (see Steve Lehmann email attachment 8/24/2012). This language was eventually dropped in the final version. In doing so, NOAA "…had a long discussion about this and the primary reason for collecting the data related to impacts on marine life." and "In addition (as stated in the introductory paragraph to the VOC section), much emphasis was out on VOC reduction as a justification for subsea dispersant use. There is no doubt in my mind that if we have a similar release, this justification will be thrown out in the first utterances by the RP." (see Steve Lehmann email – 8/7/2012). As a result, the final document states that "While this document does not specifically address worker safety, the data collected in this effort should be reported to the DEMU and the natural resource trustees to assess overall exposure to birds, marine mammals, and reptiles, all of whom breathe at the air–water interface." (page 22) and points out that "The guidance does not directly address the health and safety of spill responders or monitoring personnel, which is covered by the general site safety plan for the incident (as required by 29 CFR 1910.120). Field personnel should be trained under the Occupational Safety and Health Administration (OSHA) Hazardous Waste Operations and Emergency Response (HAZWOPER) requirements, as appropriate." (page 8)

Reference: http://www.nrt.org/Production/NRT/NRTWeb.nsf/AllAttachmentsByTitle/SA-1086NRT_Atypical_Dispersant_Guidance_Final_5-30-2013.pdf/$File/NRT_Atypical_Dispersant_Guidance_Final_5-30-2013.pdf?OpenElement

Then in 2014, BSEE funded an LSU project "…to develop real-time and passive monitoring protocols to effectively determine the impact of dispersant use and VOC release, in both surface and subsurface applications, on oil spill response worker safety.", entitled "Development of a Real-time Monitoring Protocol for Assessing VOC Impacts on Response and Cleanup Workers' Safety During Dispersant Operations". The BSEE website on the project indicates that LSU worked with NOAA and USCG to develop recommendations and countermeasures to optimize dispersant use for VOC control and worker safety under task 5. More specifically, investigators from LSU worked with Mr. Ed Levine (NOAA SSC) and Lt. Aaron Jozsef (USCG) to develop recommended monitoring protocols as well as recommendations and countermeasures to optimize dispersant use for VOC control and worker safety. **Among the recommendations for monitoring and optimizing dispersant use for VOC control and worker safety include: 1) Addition of BTEX testing within the water column as part of the Special Monitoring of Applied Response Technologies (SMART) protocol tier 3 additional monitoring plan, and 2) Recommend real-time air and water monitoring of BTEX as an optional monitoring technology available to the SMART protocol**. (page 66/67). The report also references the SMART protocol in the Roles and Responsibilities section, which indicates that the Monitoring Team Leader, Monitor Assistant, Group Supervisor, and the Technical Specialist receive SMART Monitor Training (pages72-73) and in the Refresher Training section "Review of SMART: What is it, why do it, what is it good for." (page 75)

Reference: http://www.bsee.gov/Technology-and-Research/Oil-Spill-Response-Research/Projects/Project1006/

Our understanding is that the air monitoring described in SMART is not part of the monitoring of dispersant operations, but rather associated with in-situ burning. Furthermore, the SMART protocol (v.8/2006) states that "SMART does not directly address the health and safety of spill responders or monitoring personnel, since this is covered by the general site safety plan for the incident (as required by 29 CFR 1910.120).", which is similar to the statement made in the NRT's Environmental Monitoring for Atypical Dispersant Operations document. (page 1)

Reference: http://response.restoration.noaa.gov/sites/default/files/SMART_protocol.pdf

Also in 2014, BSEE (through Lori Medley's office) funded a USCG research project to evaluate the effectiveness of the SMART protocol, entitled "Special Monitoring of Applied Response Technologies (SMART) Protocol Enhancement." This research project concluded that the 2006 SMART Protocol meets its original purpose by providing general guidance, but that SMART lacks detailed guidance for operational data collection, processing, and data evaluation and that guidance should be developed and promulgated as job aids or appendices to the main body of the protocol.

•□□□□□□□□ *The SMART Protocol should be limited to "typical" responses that last a few days and cover a limited geographic area. Other more complex responses are better suited for events such as Deep Water Horizon, which is considered to be "atypical".* (emphasis added)

The adequacy of training is another non-material gap. A routine curriculum of training on the equipment and procedures used by SMART that covers water sampling, water column profiling, and air monitoring is recommended for the Strike Teams. Also, the Strike Teams do not receive routine, comprehensive SMART Tier I training.

•□□□□□□□□ The procedures and division of responsibilities that were worked out between the USCG and NOAA during the Deep Water Horizon response effectively support the mission, and these developments *should be incorporated into the Protocol.* (emphasis added)

That methodology should be documented, along with more detailed guidance on executing the protocol. This additional guidance should be included in appendices to the basic protocol. (page vii)

Reference: http://www.bsee.gov/Technology-and-Research/Oil-Spill-Response-Research/Projects/Project1020/

Concurrently, ICCOPR was developing its Research and Technology Plan (R&T Plan) which set out its research priorities. The draft R&T plan included a recommendation to "Develop a refined SMART protocol and operational procedures for use during subsea and surface responses based on recent experiences." (page 9-15) In our review we pointed out that it was the NRT Atypical

Guidance document, and not SMART, that would apply to dispersant use situations for subsea response since SMART does not address subsea dispersant use, and offered an edit to include the phrase "or equivalent" after the term "SMART". Without that edit, it appears the draft ICCOPR recommendation could be interpreted to advocate for expanding the scope of SMART.

Reference: (email attachment from Bill Vocke (USCG) – 5/13/2015 for draft recommendation)

Then in July 2015, we were made aware that Fred Stroud (EPA-ERT) was participating in a workgroup that is drafting a SMART tactic, techniques, and procedures (TTP) document. A preliminary review notes that:

•□□□□□□□□ Subsea dispersant use is referred to in the document in several places (e.g., Section F – Atypical Dispersant Monitoring – Page 4-15 and -16)

•□□□□□□□□ Statements in the document appear contradictory or unclear (e.g., The Required Operational Capabilities (ROC) and Projected Operational Environment (POE) Requirements includes "Provide technical expertise for sub-sea dispersant application and monitoring" as a sub-bullet under "Provide technical expertise for dispersant planning, operational oversight and monitoring for Special Monitoring for Alternative Response Technologies (SMART) for surface application." (page 2-2);

•□□□□□□□□ Figure 4-4 refers to subsea dispersant injection which is in a section on SMART Tier 1 monitoring procedures (page 4-7)).

Reference: (email attachment from Fred Stroud – 7/22/2015)

We are trying to understanding the current SMART efforts to see if they will impact the scope of SMART. Understanding who has the primary responsibility in developing the SMART text has an impact on our Subpart J final rule decision-making since we received a NOAA request to include SMART in the monitoring section of a proposed rule.

•□□□□□□□□ Modify the language to, "In consultation with the OSC, and using [Special Monitoring of Applied Response Technologies guidance], characterize". The best available technologies may be excessive monitoring, pending the scenario. The SMART protocol provides guidance to responders and allows for the OSC and the EU to determine what is necessary for the specific incident. (page 2 of 4)

Reference: (email attachment from Jennifer Barr (NOAA) – 7/17/2015)

To: Wilson, Gregory[Wilson.Gregory@epa.gov]
From: Stroud, Fred
Sent: Wed 7/22/2015 2:44:39 PM
Subject: FW: SMART - TTP - IPT Stage 3 Coord Draft Meeting @ 1400/2:00pm EST / 1100-PST
CGTTP_3-75_1_SMART_20150720.doc

-----Original Message-----
From: Bowlin, Mathew T LT [mailto:Mathew.T.Bowlin2@uscg.mil]
Sent: Tuesday, July 21, 2015 9:22 AM
To: Alfonso, Arian MST1; Balsley, Alexander CIV; Bannan, Agustus J CDR; Blount, Trevor A LT; Bock, Edward L CIV; Bond, Kenneth W DC1; Brian Parscal - PP-LLC; Clark, Heather L MST2; Coburn, Craig H BOSN3; Cooper, Jonathan A LT; ed.levine@NOAA.gov; Fong, Donna M CTR; Stroud, Fred; Harms, Jesse B LT; Isom, Donald K LCDR; Kulesa, Frank R LCDR; Levine, Edwin A CIV; Mauch, Edward R MAT4; Murray, Dawn W CDR; Scott, Jason R LT; david.a.studer@uscg.mil
Subject: SMART - TTP - IPT Stage 3 Coord Draft Meeting @ 1400/2:00pm EST / 1100-PST

Greetings,

SMART ? TTP/IPT Project Develop Author뭘 Coordinated Draft Meeting schedule for Tuesday at 1400/2:00pm ? EST/1100-PST on July 21, 2015. IPT members who aren't able to access the CG SharePoint Website use the enclosed doc. Make your comments and save, and email back to Ms. Donna Fong?

Participants Telcon Num:
Telecon-Num: 712-432-0800
Pin: 1021220

v/r,

LT Tim Bowlin
Force Readiness Command (FORCECOM)
Integration Branch (FC-Pi)
300 East Main Street
Norfolk, VA 23510
? 757)628-4875

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1)
Introduction

Introduction

This tactic, techniques, and procedures (TTP) publication gives actionable, step-by-step procedures regarding the Special Monitoring of Applied Response Technologies in direct support of the policy and doctrine prescribed by reference (a), Special Monitoring of Applied Response Technologies 684-SMART (v.8/2006), reference (b), Use of Special Monitoring of Applied Response Technology Protocols, COMDTINST 16470.1 (series), and reference (c), Required Operational Capabilities (ROC) and Projected Operational Environment (POE) for Coast Guard National Strike Force, COMDTINST 3501.57A. It also defines the use of notes, cautions, and warnings in tactics, techniques, and procedures (TTP) publications.

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Section A: Introduction

A.1. Introduction

Special Monitoring of Applied Response Technologies (SMART) establishes a monitoring system for rapid collection and reporting of real-time, scientifically based information, in order to assist the Unified Command with decision-making during dispersant and in-situ burn operations in response to oil-spills.

Response procedures balance between the operational demand for rapid response and the Unified Command's need to make informed decisions based on feedback from the field. The origin of hazardous substance are typically an oil spill or hydrocarbon-based chemical spill where In-Situ burning or dispersant operations are used in fresh or marine water or on land. SMART procedures can also be adapted to hazardous air emissions.

This TTP publication cannot cover every Special Monitoring of Applied Response Technologies scenario that might arise. You may deviate from the TTP as necessary to complete the task with greater safety, effectiveness, or efficiency. Do not take such deviations lightly. Temper any decision to deviate with maturity and a complete understanding of the mission, members' capabilities, and equipment. Whenever possible, consult your unit chain of command prior to deviation. Any deviations to the TTP should be documented. Report TTP adjustment needs per the Request for Changes paragraph located in the letter of promulgation.

A.2. Scope

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Figure 1-1 Incident Command Post (ICP)

This TTP provides National Strike Force (NSF) personnel with a protocol for rapid collection of real time, scientifically based information, to assist the Unified Command (UC) with decision making during dispersant applications and in-situ burning operations.

A.3. Audience

The audience for this TTP publication is the National Strike Force (NSF), Scientific Support Coordinators (SSC), Federal On Scene Coordinator (FOSC) and Unified Command (UC).

A.4. Incident Command System principles

SMART Monitoring operations are conducted under the Incident Command System (ICS) and in keeping with incident command principals. Addition details are found in reference (d), Coast Guard Incident Management Handbook, COMDTPUB P3120.17 (series).

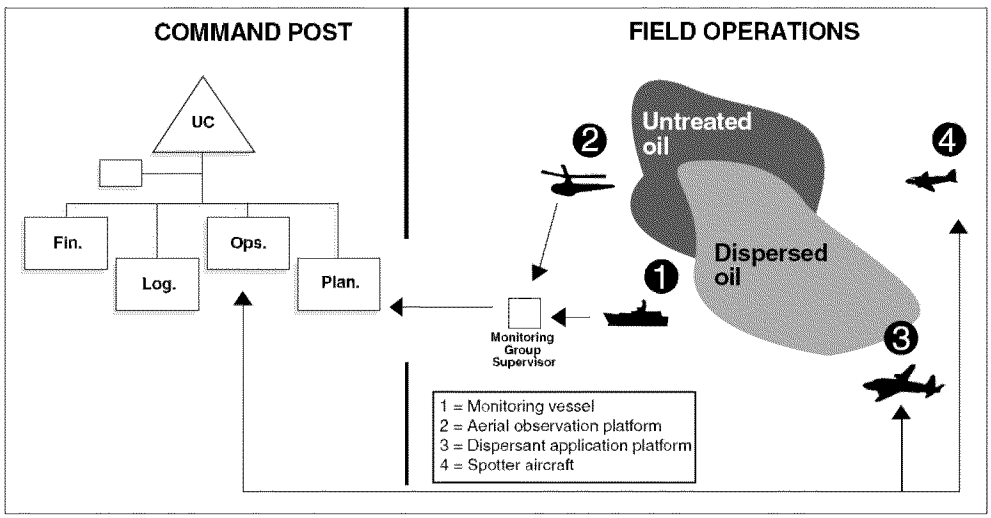

Figure 1-2 Command, control and data flow during dispersant monitoring operations

A.5. Integration of Sources

Integrate personnel and resources from diverse federal, state, local, and private sector organizations.

As each incident is different, the supporting organizational structure will also differ. Reference the current version of reference (d), Coast Guard Incident Management Handbook (Chapters 6, 7, 8, and 20) to determine the most effective means of fashioning a SMART team into the Incident Command Structure).

A.6. Roles and Responsibilities

The following are the roles and responsibilities within SMART Monitoring operations.

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A.6.a. National Strike Force (NSF)	In order to protect public health and the environment, the NSF prepares for and responds to oil and hazardous substance pollution by providing to the Coast Guard and other federal agencies: • highly trained and experienced personnel • specialized equipment The NSF's area of responsibility covers all Coast Guard Districts and Federal Response Regions. The NSF is made up of 200 active duty, civilian, reserve, and auxiliary personnel and includes the National Strike Force Coordination Center (NSFCC); the Atlantic Strike Team; the Gulf Strike Team; and the Pacific Strike Team. During SMART operations the National Strike Force provides, highly mobile teams who collect real-time data using portable, rugged, and easy-to-use instruments during dispersant and in situ burning operations. These field teams provide data which is sent to the Unified Command to address critical questions such as: • Are particulate concentration trends exceeding the level of concern for the public? • Are dispersants effective in dispersing the oil?
A.6.b. National Oceanic and Atmospheric Administration (NOAA) – OR&R & SSC	During an oil spill in coastal waters, the Office of Response and Restoration (OR&R) within NOAA provides scientific support to the U.S. Coast Guard Federal On-Scene Coordinators (FOSC). During a response, the SSC serves on the FOSC's staff and may, at the request of the FOSC, lead the scientific team and be responsible for providing scientific support for operational decisions and for coordinating on-scene scientific activity. Depending on the nature and location of the incident, the Scientific Support Coordinators (SSC) integrates expertise from governmental agencies, universities, community representatives, and industry to assist the OSC/RPM in evaluating the hazards and potential effects of releases and in developing response strategies. A technical specialist (e.g. dispersants specialist) will communicate SMART monitoring results and information from the Monitoring Group Supervisor, interpret data and formulate recommendations to persons in the Unified Command.
A.6.c. Environmental Protection Agency (EPA)	One of the Environmental Protection Agency's roles is to help protect the environment and human health from releases or discharges of oil, chemicals, or other hazardous substances by managing emergencies and regulating response. Because oil spills may impact the environment, the EPA and the regulated community aim to prevent, prepare for, and respond

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to oils spills of all types.

EPA is the lead federal response agency for oil spills occurring in inland waters, and the U.S. Coast Guard is the lead response agency for spills in coastal waters and deepwater ports.

A.6.d. Centers for Disease Control and Prevention (CDC) - NIOSH

As part of the CDC, the National Institute for Occupational Safety and Health (NIOSH) is responsible for conducting research and making recommendations for the prevention of work-related illnesses and injuries.

NIOSH research scientists conduct toxicology studies on the dispersants used in responses to crude oil, and dispersant and crude oil mixtures. These chemicals and chemical mixtures are being tested for possible adverse health effects of pulmonary and dermal exposure.

NIOSH develop recommendations for protecting workers from the potential effects of chemicals and chemical mixtures.

A.6.e. Incident Command Post (ICP)

Figure 1-3. Incident Command Post

The Incident Command Post (ICP), as defined in reference (d), Coast Guard Incident Management Handbook COMDTPUB P3120.17 (series), is the field location at which the primary tactical-level, on-scene incident command functions are performed. The Incident Command Post may be collocated with the incident base or other incident facilities.

A.6.f. Federal On-

Federal official charged with coordinating and directing removal actions with consistent, real-time, and scientifically based data necessary to make

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scene Coordinator (FOSC)	informed operational decisions.
A.6.g. Monitoring Group Supervisor (MGS) & Team	The Monitoring Team Group Supervisor directs and coordinates team operations. The Supervisor is a part of the Incident Command Center (ICS) and is reports to the Operations Section Chief. Examples of a Group Supervisor would include In-Situ Burn Monitoring Group Supervisor (ISB-MGS). The roles and responsibilities of an ISB-MGS can be found in the reference (d), Coast Guard Incident Management Handbook, COMDTPUB P3120.17 (series), Chapter 20 - Oil Spill.
A.6.g.(1). Visual Monitoring Team	A Visual Monitoring team consists of the monitor (team lead) & the assistant monitor. There can be an additional team member to help with sampling and recording.
A.6.g.(2). Water Column Monitoring Team	A Water Column Monitoring team consists of monitor (team lead) & assistant monitor.
A.7. General Considerations and Assumptions	Several considerations guided the workgroup in developing SMART guidelines: 1. SMART is designed for use at oil spills both inland and in coastal zones, as described in the National Oil and Hazardous Substances Pollution Contingency Plan. 2. SMART does not directly address the health and safety of spill responders or monitoring personnel, since this is covered by the general site safety plan for the incident ,as required by reference (e), Hazardous waste operations and emergency response, 29 CFR Part 1910.120, Subpart H 3. SMART does not provide complete training on monitoring for a specific technology. Rather, the program assumes that monitoring personnel are fully trained and qualified to use the equipment and techniques mentioned and will follow the SMART guidelines. 4. SMART attempts to balance feasible and operationally efficient monitoring with solid scientific principles. 5. In general, SMART guidelines are based on the roles and capabilities of available federal, state, and local teams, and NOAA's Scientific Support Coordinators (SSC). The SSC most often fills the role of Technical Specialist. Users may adopt and modify the modules to address specific needs. 6. SMART uses the best available technology that is operationally practical. The SMART modules represent a living document and will be revised and improved based on lessons learned from the field, advances

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in technology, and developments in techniques.

7. SMART should not be construed as a regulatory requirement. It is an option available to the Unified Command to assist in decision-making. While every effort should be made to implement SMART or parts of it in a timely manner, In-Situ burning or dispersant application should not be delayed to allow the deployment of the SMART teams.
8. SMART is not intended to supplant private efforts in monitoring response technologies, but is written for adoption and adaptation by any private or public agency. Furthermore, users may choose to tailor the modules to specific regional needs.
9. It is important that the Unified Command agree on the monitoring objectives and goals early on in an incident. This decision, like all others, should be documented.

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Section B: Notes, Cautions, and Warnings

B.1. Overview

The following definitions apply to notes, cautions, and warnings found in TTP publications.

NOTE: **An emphasized statement, procedure, or technique.**

CAUTION: **A procedure, technique, or action that, if not followed, carries the risk of equipment damage.**

WARNING: ***A procedure, technique, or action that, if not followed, carries the risk of personnel injury or death.***

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2)
SMART Training

Introduction

This chapter discusses internal and external training for SMART monitoring.

In This Chapter

This chapter contains the following sections:

Section	Title	Page
A	Introduction	2-2
B	External Training	2-4
C	Internal Training	2-6

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Section A: Introduction

B.1. Approved Training

Coast Guard personnel assigned to SMART Operations should be certified under the Response Member (RM) qualifications, developed by the National Strike Force Coordination Center (NSFCC) and the National Strike Force Center of Expertise (NSF COE). Typically, National Strike Force members are the only ones who will receive SMART training. That training may be provided internally by the NSF itself, or externally from contractors.

SMART team members can receive either internal or external training, or both. The training provided by either source will overlap as the goal of the training is the same. And though the training may come from different sources, NSF members are the only ones that can sign off on the qualifications.

All Coast Guard SMART members conducting SMART Operations are trained under approved U.S. Coast Guard qualification standards.

The link below directs you to NSF.

http://www.uscg.mil/hq/nsfweb/default.asp

https://training.fema.gov/emi.aspx

B.2. Prerequisites

At a minimum, personnel conducting SMART Operations should have completed the following training:

- Response Member (RM) qualification
- SMART protocols and Equipment Training

B.3. ROC and POE Requirements

The Required Operational Capabilities (ROC) and Projected Operational Environment (POE) for the National Strike Force (NSF) states that the NSF must provide to Federal On-scene Coordinators (FOSC) the following training:

- Provide technical expertise for dispersant planning, operational oversight and monitoring for Special Monitoring for Alternative Response Technologies (SMART) for surface application.
    - Provide technical expertise for sub-sea dispersant application and monitoring.
    - Conduct dispersant effectiveness monitoring.

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Provide expertise for the oversight of in-situ burn operations.

- Conduct in-situ burn monitoring (SMART).
- Provide technical expertise for the planning and execution of in-situ burn operations

NOTE: **May require the technical expertise of NOAA Scientific Support Coordinators.**

B.4. Needed Training

Figure 2-1 Aerial Observation

Below is a summary of the training modules needed for a comprehensive SMART training program. In most cases, annual training with an SME is needed, along with semi-annual in-house refresher training. Experience demonstrates that a large-scale response (such as the DWH) may require the deployment of multiple SMART field teams, separately monitoring both dispersant and burn operations simultaneously. This may also involve Strike Team personnel from different regions joining forces to form a single SMART field team, and standardizing the training curriculum and requirements across units is an important aspect.

- Overall SMART Mission.
- Tier I Aerial Observation.
- SMART Aerial Spotting.
- Tier II/III Fluorometry Data Collection.
- Tier II/III Water Sampling.
- Tier III Water Parameter Collection.
- In-Situ Burn (ISB) Air Monitoring.

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C.1. Introduction

There is no mandate for external training. External training is where a contractor provides comprehensive training that responders can attend. The NSF Strike Teams will hold hands-on training in conjunction with classroom training. The National Strike Force Center of Expertise (COE) will coordinate any external training.

C.2. External Contractor training

The National Strike Force (NSF) provides protocols on SMART Training for National Strike Force Strike Teams. Training is used for monitoring In-Situ burning (ISB) and air monitoring in oil spills. This will include an overview of fluorometry, dispersants, and dispersant operations as used in an oil spill response environment.

Annual/initial trailing will include:

- Overall SMART Mission.
- Tier I Aerial Observation.
- SMART Aerial Spotting.
- Tier II/III Fluorometry Data Collection.
- Tier II/III Water Sampling.
- Tier III Water Parameter Collection.
- ISB Air Monitoring.

C.3. Aerial Observation Course

Strike Team members are frequently needed to observe oil spills on water from the air. They provide critical eyes in the sky for USCG response teams and NOAA's Office of Response and Restoration. Oil spill responders use a common terminology for describing and reporting oil spills.

Go to NOAA's website for Training: Aerial Observation of Oil Spills for the link to their online training.

http://response.restoration.noaa.gov/training-and-education/training/workshops/aerial-observation-training.html

http://response.restoration.noaa.gov/sites/default/files/OWJA_2012.pdf

This lesson teaches members how to identify, describe, and report spills using accepted terminology. Misidentifying natural events as oil spills is a common, and sometimes expensive, mistake. This lesson also points out common false positives when trying to identify oil spills.

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At the end of this lesson, the learner will be able to do the following:

- Accurately report oil sightings using standard terminology
- Provide the critical information most useful to pollution responders
- Recognize false positives
- Work effectively with trained observers

The American Society for Testing and Materials (ASTM) standard: F1779 - 08(2014) that covers Standard Practice for Reporting Visual Observations of Oil on Water is covered in this course. This ASTM standard can be found through the DHS Library on the DHS homepage http://dhsconnect.dhs.gov/org/comp/mgmt/cio/esdo/ADM/information-governance/library/Pages/Standards-and-Specifications.aspx

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Section D: Internal Training

D.1. Introduction

Unit level training will be conducted per the NSF responder development program and the unit training plan. This ensures responders maintain proficiency with SMART equipment and monitoring procedures with a special emphasis on hands on training.

D.2. Minimum Suggested Training

Below is a summary of the training modules that should be included in a comprehensive SMART training program.

- Overall SMART Mission
- SMART Aerial Spotting
- Tier I Aerial Observation
- Tier II/III Fluorometry Data Collection
- Tier II/III Water Sampling
- Tier III Water Parameter Collection
- ISB Air Monitoring

D.3. Training Exercises

Hands on exercises needs to be conducted on the below equipment to ensure all NSF Strike Team members are proficient in their use and data collection:

1. Radios and Satellite Communications Equipment
2. Photography Equipment
3. Fluorometer
4. Water Sampling Equipment
5. Particulate Air Monitors
    a. Operating instructions
    b. Calibration check
    c. Inspection checklist
    d. Maintenance procedures
    e. Inspection and maintenance schedule

D.4. Ready For Operations Exercises

Strike Team Training Coordinators need to ensure that team members are proficient at the exercises in reference (f), the National Strike Force Strike Team (NSFST) Ready for Operations (RFO) instruction (NSF INST

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In the NSF Ready for Operations Checklist/Oil Spill Response are the following sections:

- Demonstrate thorough knowledge of Special Monitoring for Applied Response Technologies (SMART) for dispersants (Section 6 of ROE reference (https://cgportal2.uscg.mil/units/nsfcc/Shared%20Documents/2015%20NSF%20References/NSF%20READY%20FOR%20OPERATIONS%20(RFO)%20PROGRAM-2010%20(NSFINST%203501.1).pdf
- Demonstrate thorough knowledge of Special Monitoring for Applied Response Technologies (SMART) for in-situ burn (Section 7 of ROE https://cgportal2.uscg.mil/units/nsfcc/Shared%20Documents/2015%20NSF%20References/NSF%20READY%20FOR%20OPERATIONS%20(RFO)%20PROGRAM-2010%20(NSFINST%203501.1).pdf

All Coast Guard SMART members with authority to certify SMART Operations are qualified under approved U.S. Coast Guard qualification standards.

National Strike Force website: http://www.uscg.mil/hq/nsfweb/default.asp

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4)
In-Situ Burn Monitoring

Introduction

This chapter provides a basic overview of In-Situ burn principles and operations. SMART focuses on the safe monitoring of In-Situ burn operations. In-Situ burn monitoring is a critical component of starting and stopping the response operations. The general rule is when the public has the potential to be affected by the burning of oil, SMART monitoring should be utilized.

In each team's inventory, there is a real-time particulate monitor to detect small particulates (ten microns in diameter or smaller) generated by the burning of oil. Each monitoring instrument displays and logs the instantaneous particulate concentration, as well as a time weighted average (TWA) concentration. The particulate concentration is passed to the NOAA SSC to determine if the burn is producing unsafe working conditions for responders or if the public is in danger.

In This Chapter

This chapter contains the following sections:

Section	Title	Page
A	Introduction	3-2
B	Preparation and Pre-Response Procedures	3-3
C	In-Situ Equipment List	3-5
D	Data Evaluation	3-10
E	Post Response Operations	3-11

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Section A: Introduction

A.1. General Considerations

In-Situ burning of oil may offer a logistically simple, rapid, and relatively safe means for reducing the net environmental impact of oil spills. Because a large portion of the oil is converted to gaseous combustion products, in situ burning can substantially reduce the need for collection, storage, transport, and disposal of recovered material.

In situ burning, however, has several disadvantages: burning can take place only when the oil is not significantly emulsified, when wind and sea conditions are calm, and when dedicated equipment is available. In addition, in situ burning emits a plume of black smoke, composed primarily (80-85%) of carbon dioxide and water. The remainder of the plume is gases and particulates, mostly black carbon particulates, known as soot. These soot particulates give the smoke its dark color. Downwind of the fire, the gases dissipate to acceptable levels relatively quickly. The main public health concern is the particulates in the smoke plume.

A.2. Public exposure to smoke from burns

In general, SMART is conducted when there is a concern that the general public may be exposed to smoke from the burning oil. It follows that monitoring should be conducted when the predicted trajectory of the smoke plume indicates that the smoke may reach population centers, and the concentrations of smoke particulates at ground level may exceed safe levels.

Execution of In-Situ burning has a narrow window of opportunity. It is imperative that the monitoring teams are alerted of possible In-Situ burning and SMART operations as soon as burning is being considered, even if implementation is not certain. This increases the likelihood of timely and orderly SMART operations.

NOTE: **Monitoring is not required when impacts are not anticipated.**

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Section B: Preparation and Pre-Response Procedures

In-Situ Burn Plan

Response situations expose personnel, and sometimes the general public, to potentially hazardous situations. In-Situ burn (ISB) operations add an additional element to safety considerations. The precautions necessary for the safety of personnel in an ISB response effort must include safety protocols for burning.

An In-Situ Burn plan includes those elements unique to ISB. This plan is designed as an appendix to the site safety plan for the overall response. The sample is not a standard, but rather a suggested starting point.

The plan contains some operational aspects which may create redundancy with ISB operations plans.

A typical plan would include the following:

- ISB site description (location of burn and monitoring devices)
- Burn objectives
- Response organization (communication)
- Burn area control
- Hazard evaluation
- Personal protective equipment
- Decontamination procedures
- Training and site safety meetings

A plan is often very fluid because of changing weather conditions. If there is no public health risk, monitoring of in-situ burn is not performed.

Below is a link to an example of a site safety plan for marine In-Situ burn operations.

http://response.restoration.noaa.gov/sites/default/files/NAVY_sample_site_safety_ISB.pdf

---

B.1. Communication Plan

Part of ICS, 205?

From aircraft to the ground to the Unified Command and Scientific Coordinator. Identify working channels.

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CAMSLANT can patch airplanes to Command, via a secure line.

Refer to the communication plan to identify the communication lines from the SMART monitoring teams to SSC.

Does monitoring team need a direct line to SSC? A way to contact the burn team and SSC.

B.2. Deployment of personnel

Generally, a SMART monitoring team has a minimum of two members. However, this is scalable for larger incidents. The size of the incident will determine the number of teams required.

B.3. Deployment of vessels and aircrafts

A dedicated aircraft maybe required during in-situ burn operations depending on the proximity to a dense population.

Dedicated vessels are required during In-Situ burn operations. Distance off shore, number of burns, proximity to population center, will dictate the number of vessels deployed for operations and monitoring.

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Section C: In-Situ Equipment List

D.1. Introduction

The following is a list of equipment that is suggested for monitoring In-Situ burns but is not meant to be comprehensive nor representative of what will be available to each SMART team. Each incident will be unique in its equipment needs and must be adjusted accordingly.

Ensure equipment is present, purchased and calibrated.

D.2. List of equipment

For a complete list of equipment and procedures see Chapter 5 and Job aid check list (updating current job aid (attachment 4) will be done by LT Harms)

- Particulate monitoring instrument, accessories and manuals, 1 or more
- Computer and cables, 1/group. Should include downloading software
- Printer, 1/group
- Recorder data sheets
- ICS 214, Daily unit log
- Write-in-the-rain notebooks, pens
- GPS
- Extra batteries for GPS
- Radio
- Cell phone
- Binoculars
- Stop watch
- Camera
- Digital camera or camcorder optional
- Thermometer
- Humidity meter
- Anemometer

NOTE: **Fill out a DD-1149, REQUISITION AND INVOICE/SHIPPING DOCUMENT for property transfer.**

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Section E: Monitoring Procedures

E.1. Introduction

SMART Operators must be aware of the monitoring procedures contained in this section before beginning a Monitoring Operation.

GULF OF MEXICO – A controlled burn in the Gulf of Mexico is monitored by members of Industry and Coast Guard Gulf Strike Team personnel. Photo courtesy of U.S. Navy

Figure 3-1 Monitoring In-Situ Burn Operations

E.2. Monitoring locations

Monitoring locations are dictated by the potential for smoke exposure to human and environmentally sensitive areas. Taking into account the prevailing winds and atmospheric conditions, the location and magnitude of the burn, modeling output (if available), the location of population centers, and input from state and local health officials, the monitoring teams are deployed where the potential exposure to the smoke may be most substantial (sensitive locations). Precise monitoring locations should be flexible and determined on a case-by-case basis. In general, one team is deployed at the upwind edge of a sensitive location. A second team is deployed at the downwind end of this location. Both teams remain at their designated locations, moving only to improve sampling capabilities. A third team is more mobile and is deployed at the discretion of the ISB-MGS.

It should be emphasized that, while visual monitoring is conducted continuously as long as the burn takes place, air

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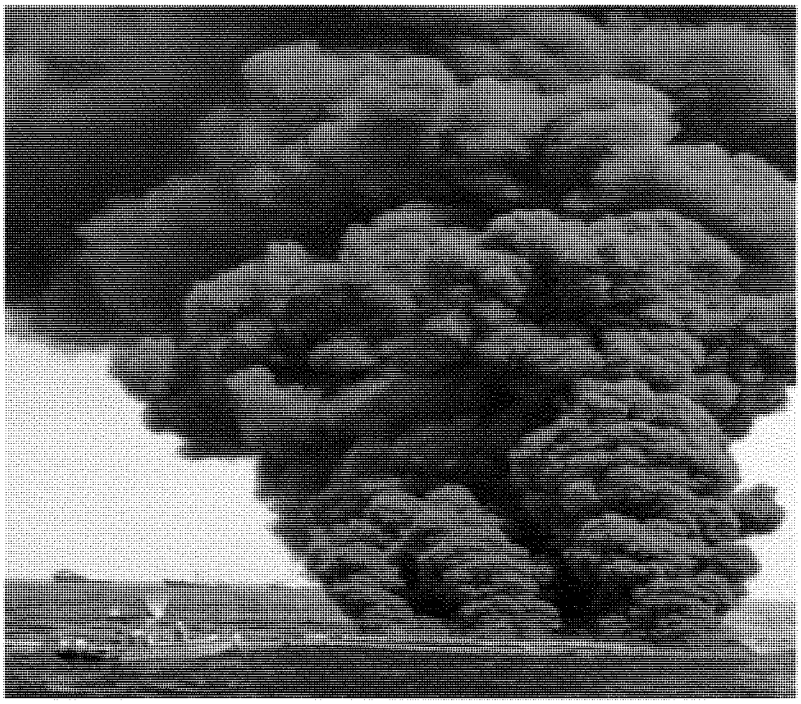

Figure 3-2 In-Situ Burn Operations

Figure 3-3. In-Situ Burn Operations

E.3. Data Collection

done on site with instruments

data is saved locally on non-standard laptops

The specific monitoring locations will be determined by the SSC.

NOTE: **Frank email CFR document: All monitoring will be saved on**

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computer.

CAUTION: **Follow manufacturer's guidance for equipment usage. Ignoring it can result in malfunction.**

WARNING: ***NSF responders follow the incident site specific safety plan. Lack of adherence to technique or action carries the risk of personnel injury or death.***

E.4. Data Processing

The data processing involves downloading the data off of the Data Ram and calculating the TWA (Time Weighted Average).

See Appendix D for example of raw data from the DataRAM

E.5. Information Flow

As each incident is different, the supporting organizational structure will also differ. Reference the current version of the Incident Management Handbook (Chapters 6, 7, 8, and 20) to determine the most effective means of fashioning a SMART team into the Incident Command Structure).

However, in general the observation and monitoring data will flow from the Monitoring Teams to the Monitoring Group Supervisor. The Group Supervisor forwards the data to the Technical Specialist/Environmental Group. The Technical Specialist or his/her representative reviews the data and, most importantly, formulates recommendations based on the data. The Technical Specialist communicates these recommendations to the Unified Command.

Quality assurance and control should be applied to the data at all levels. The Monitoring Group Supervisor/Technical Specialist is the custodian of the data during the operation, but ultimately the data belongs to the Unified Command. The Unified Command should ensure that the data is properly archived, presentable, and accessible for the benefit of future monitoring operations. paste in figures 1 and 2 of section 3.2 of 8/2006 document

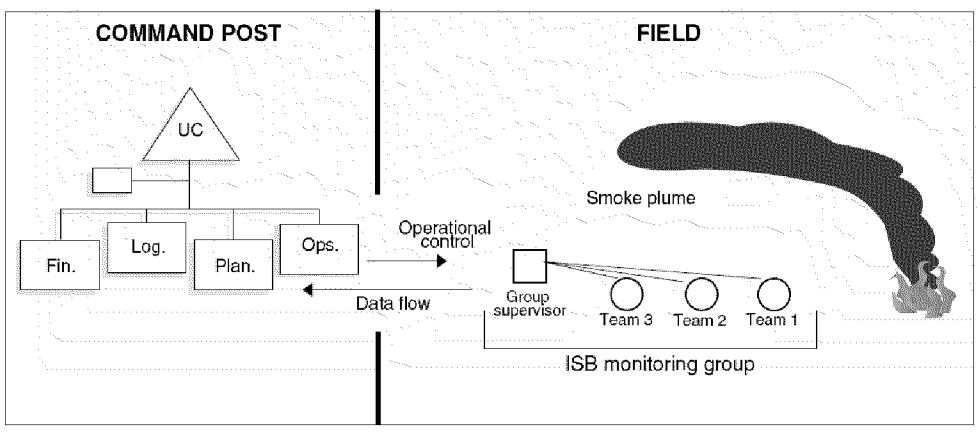

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Figure 3-4. Command, control, and data flow during in-situ burning monitoring operations

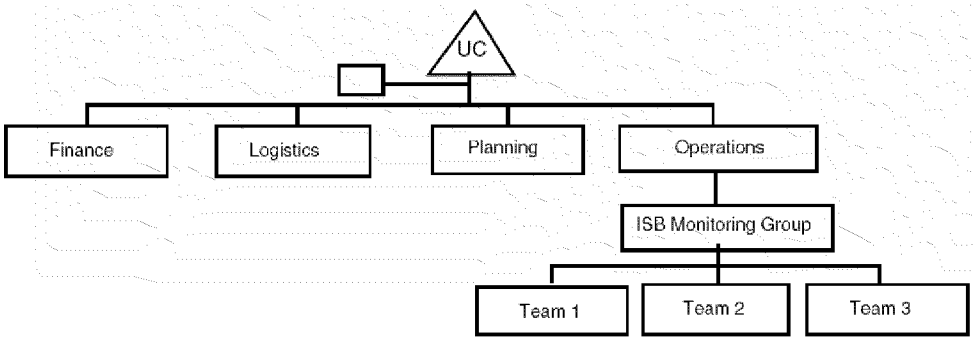

Figure 3-5. ISB Monitoring Group in the ICS organization

E.6. Data Transmission

Data is sent to the SSC typically through the use of satellites and satellite phones.

Further communication with Communication Working Group (Elizabeth City, NC), is needed to flesh out this section.

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Section F: Data Evaluation

G.1. Introduction

Figure 3-6 USCG SMART team

This section discusses various monitoring procedures, data evaluation that the SMART Operators must be aware of before beginning a Monitoring Operations.

SSC's role and/or SMART team lead? Let Ed Levine decide.

Note to Ed: Tactics language might be considered here from the Volume Estimation Protocol for controlled burns.

From SMART Project Memo, 20 October 2014, SMART lacks detailed operational guidance for data collection, processing, and data evaluation.

G.2. Data Collection

G.3. Data Evaluation

Done by NOAA.

G.4. Communication of Data and Results

This TTP applies to NSF SMART monitoring personnel working for either a Coast Guard FOSC or EPA On-Scene Coordinator, per National Contingency Plan.

ADD THE ABOVE TO APPROPRIATE LOCATION IN CHAPTER 1

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Section H: Post Response Operations

H.1. Decontaminating Equipment

instrument decontamination or send back to manufacturer for maintenance? follow recommended maintenance intervals.

report all equipment malfunctions to group supervisor and response supervisor (RS). Fill out a DD-1149, REQUISITION AND INVOICE/SHIPPING DOCUMENT for property transfer.

H.2. Data dump

Archiving note of data in case file

NOTE:

Per 40 C.F.R. 300.315, the FOSC is required to collect and maintain documentation of all actions taken under the Clean Water Act to support cost recovery, scientific understanding of the environment, and research and development. The FOSC is required to make available this documentation to trustees of affected natural resources.

In order to meet this requirement, SMART Monitoring teams shall save all ISB monitoring data and provide electronic and/or hard copies to the following:

1. Incident Command Post Documentation Unit Leader

2. NSF Strike Team Case File

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5)
Dispersant Monitoring

Introduction

This Chapter discusses various Dispersant Monitoring procedures, for Tier I – III, and Atypical Dispersant that the SMART Operators must be aware of before beginning Dispersant Monitoring Operations.

Jesse to provide content and details.

In This Chapter

This chapter contains the following sections:

Section	Title	Page
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D	Tier II Monitoring Procedures	4-9
E	Tier III Monitoring Procedures	4-12
F	Atypical Dispersant Monitoring	4-15

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Section A: Introduction

A.1. When dispersants are used during spill response, the Unified Command needs to know whether the operation is effective in dispersing the oil. The SMART dispersant monitoring module is designed to provide the Unified Command with real-time feedback on the efficacy of dispersant application. Data collected in Tier III of the SMART dispersant protocol may be useful for evaluating the dilution and transport of the dispersed oil.

NOTE: **SMART does not monitor the fate, effects, or impacts of dispersed oil.**

A.2.

A.3.

A.4.

A.5.

A.6.

A.7.

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Section B: Preparation and Pre-Response Procedures

B.1. Bring NOAA Dispersant Application Observer Job Aid and

B.2. Dispersant application has a narrow window of opportunity. Time is of the essence and timely notification is critical. It is imperative that the monitoring teams and technical advisors are notified of possible dispersant application and SMART monitoring deployment as soon as they are considered, even if there is uncertainty about carrying out this response option. Prompt notification increases the likelihood of timely and orderly monitoring.

The characteristics of the spill and the use of dispersants determine the extent of the monitoring effort and, consequently, the number of teams needed for monitoring. For small-scale dispersant applications, a single visual monitoring team may suffice. For large dispersant applications several visual and water-column monitoring teams may be needed.

B.3.

B.4.

B.5.

B.6.

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Section C: Tier I Monitoring Procedures

D.1. Introduction

Tier I employs the simplest operation, visual monitoring, which may be coupled with Infra Red Thermal Imaging or other remote detection methods.

The goal of Tier I monitoring is to identify oil, visually assess efficacy of dispersants applied to oil, and report the observations to the Unified Command with recommendations. The recommendations may be to continue, to modify, or to evaluate further monitoring or use because dispersants were not observed to be effective.

NOAA Dispersant Application Observer Job Aid is recommended for consistency. Observations should be photographed and videotaped to help communicate them to the Unified Command, and to better document the data for future use.

When available, visual monitoring may be enhanced by advanced sensing instruments such as infrared thermal imaging. These and other devices can provide a higher degree of sensitivity in determining dispersant effectiveness.

Visual monitoring is relatively simple and readily done. However, visual observations do not always provide confirmation that the oil is dispersed. Tier II provides a near real-time method using water column monitoring via a direct reading instrument and water sampling.

D.2. Preparation and Pre-Response Procedures

Bring camera and infrared camera and GPS. Tier I employs the simplest operation, visual monitoring, which may be coupled with Infra Red Thermal Imaging or other remote detection methods.

Secure dedicated aircraft.

D.3. Camera use

https://cgportal2.uscg.mil/communities/hp/HPCenter/Pubs/CGTTP_3-95_11_Precision_Marksmanship.pdf

Need additional content/details...

Ed Levine: with GPS's also w/o GPS...

LT Jason Scott: Team to work on providing details...

Video Camera: provide additional impact. minimum megapixel, zoom,

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GPS, how to geotag and how to download the GPS track and digital pictures to geotag each photo

- camera with GPS
- camera without GPS
- video camera – there are no standard video cameras but video is also helpful during monitoring procedures.

D.4. Monitoring Procedures

The following are steps in the visual monitoring of dispersant.

Placeholder for monitoring Tier I form.

D.5. Data Collection

Figure 4-1. Aero Observations Fix Wing

For best viewing, keep the sun behind you, holding the aircraft at an altitude of 500 to 1,000 feet (150 to 300 meters) while you observe the slick at about a 30-degree angle.

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Figure 4-2. Aero Observations Rotary Wing

Different observers at the same site can reach different conclusions about how much of the slick has been dispersed. To make it easier for observers to achieve consensus during a response, use standard reporting criteria and be sure that all observers have been trained to use a common set of guidelines. (Check our Open Water Oil Identification Job Aid to learn about reporting standards.)

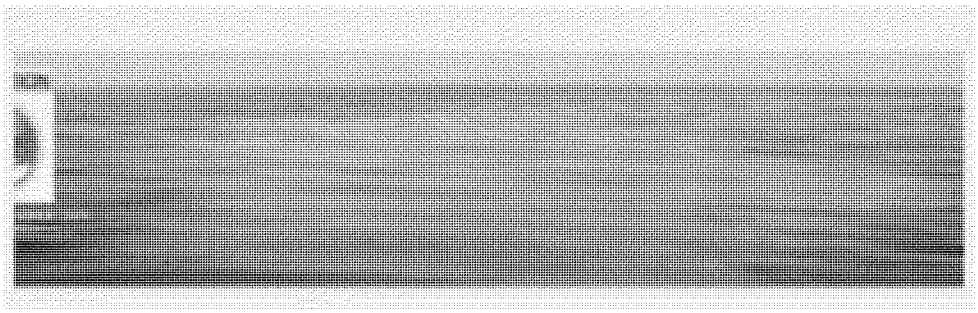

Figure 4-3. Sea Dispersant Application

You will find that observation is especially difficult under low-contrast conditions (e.g., twilight or haze).

As a monitoring observer, you will not make operational decisions, such as deciding how much dispersant to apply, or when or where to apply it. These decisions are made by operational units.

A visible subsurface plume of dispersed oil indicates that an application of dispersant is working. When no plume is visible in the water column, it is difficult to determine whether the dispersant is working but does not definitively mean that the dispersant is not having an effect.

Subsurface plumes of dispersed oil typically have a cloudy appearance,

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and can range in color from brown to white. Some are not visible. When dispersant is working, oil remaining on the water surface also may change color.

In some cases, you may not be able to see a subsurface plume even when one is present. When the water is turbid, you may not be able to see a plume. Sometimes, remaining surface oil and sheen can mask oil dispersing under the slick, making it hard for you to see the plume.

A subsurface plume may not form instantaneously once dispersant has been applied to a slick. In some cases, such as when oil is emulsified, it can take several hours for a plume to form. In other cases, a visible plume may not form (you then may wish to use sampling to learn whether dispersion has occurred).

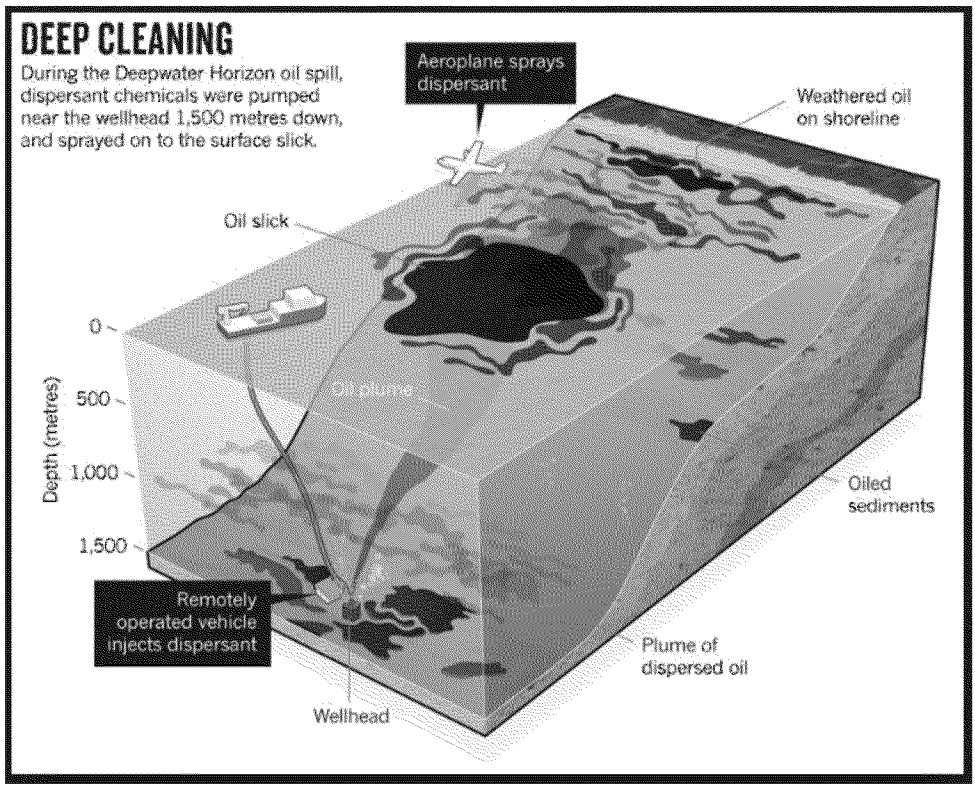

Figure 4-4. Subsea dispersant injection

A change in the appearance of a treated slick, compared with an untreated slick, might indicate that the dispersant is working. However, a difference in appearance alone is not enough of an indication to be sure that the dispersant is having an effect.

A clear stretch of water left in the wake of a dispersant application vessel can appear to represent successful dispersion of oil. However, areas of clear water can be created as the vessel wave breaks a path through the oil.

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either physically parting the oil or mechanically dispersing it. Mechanically dispersed oil will re-coalesce and float to the surface.

When initially applied, dispersants sometimes have a herding effect on oil, making a slick appear to be shrinking when, in fact, the dispersant is "pushing" the oil together. This effect results from the surfactant action of dispersants, which exerts a horizontal spreading force on thin oil films. This effect can cause parts of an oil slick to seem to disappear from the sea surface for a short time.

CAUTION: **Be sure to report the presence of marine mammals, turtles, and birds in the area of dispersant application. These species can be adversely affected by contact with dispersants.**

D.6. Data Evaluation

SSC will be evaluating visual observation data.

D.7. Communication of Data/Results

Wait for Comms group. Specifically aircraft to ground. Data does not need to be classified.

D.8. Post Response Operations

Section E: Tier II Monitoring Procedures

F.1. Introduction

Tier II combines visual monitoring with on-water teams conducting real-time water column monitoring at a single depth, with water-sample collection for later analysis. While fluorometry remains the most technologically advantageous detection method, other approaches may be considered. The performance-based guidelines provided in attachment 10 define SMART Dispersant Module Criteria for instrument selection and validation

Tier II prescribes single depth monitoring at 1-meter but rough field conditions may force continuous flow monitoring at increased depths of up to 2 meters. Water sampling may be conducted in concert with in-situ monitoring rather than collecting samples from the flow-through hose. Such a change may reduce direct comparisons between field instrument and laboratory verifications, but the data is still expected to meet mission requirements.

A water-column monitoring team composed of at least one trained

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technician and a support person is deployed on a suitable platform. Under ideal circumstances, the team collects data in three primary target locations: (1) background water (no oil); (2) oiled surface slicks prior to dispersant application, and (3) post-application, after the oil has been treated with dispersants. Data are collected in real-time by both a built-in data-logging device and by the technician who monitors the readings from the instrument's digital readout and records them in a sampling log. The sampling log not only provides a backup to the data logger, but allows the results to be communicated, near real-time, to the appropriate technical specialist in the Unified Command. Data logged by the instrument are used for documentation and scientific evaluation.

The field team should record the time, instrument readings, and any relevant observations at selected time intervals. Global Positioning System (GPS) instruments are used to ascertain the exact position of each reading.

If feasible, water samples should be collected in bottles to validate and quantify monitoring results. Samples should be collected at the outlet port or discharge side of the monitoring instrument to ensure the integrity of the readings. Exact time and position is noted for each sample taken to correlate the instrument reading. The number of water samples taken reflects the monitoring effort. Generally, five samples collected for each data run is considered adequate in addition to background samples. The water samples are stored in a cooler and sent to a laboratory for future analysis.

Data are collected in real-time by both a built-in data-logging device and by the technician who monitors the readings from the instrument's digital readout and records them in a sampling log. The sampling log not only provides a backup to the data logger, but allows the results to be communicated, near real-time, to the appropriate technical specialist in the Unified Command. Data logged by the instrument are used for documentation and scientific evaluation.

F.2. Preparation and Pre-Response Procedures

Ensure that there is a dedicated CG or contracted vessel for the duration of SMART monitoring. Coordinate through the Unified Command. CG-213RR? Follow equipment Job Aid for Tier II/III monitoring.

F.3. Equipment

See equipment list in Chapter 5.

F.4. Monitoring Procedures

Under ideal circumstances, the team collects data in three primary target locations: (1) background water (no oil); (2) oiled surface slicks prior to dispersant application and (3) post-application, after the oil has been treated with dispersants.

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F.4.a. Vessel Requirements	For offshore SMART response recommend offshore supply vessel with adequate crew space for team rest/comfort. Recommend 100 square foot minimum deck space for flourometer setup and use. Ability or room to install antenna for air frequency radio is essential for communications with dispersant spotter aircraft. Near shore (<10 miles) any vessel with adequate deck space will suffice with the same consideration for radio communication.
F.4.b. Background measurements	• Background water – what is in the water adjacent to the oil slick • Surface oil (prior to dispersant application)
NOTE:	**The vessel used for near shore operations should be appropriate for the sea state or anticipated sea state. The sea state should be analyzed to determine the ability of the selected vessel to handle anticipated marine conditions prior to getting underway.**
F.4.c. Dispersant measurement	• Tier II prescribes single depth monitoring at 1-meter but rough field conditions may force continuous flow monitoring at increased depths of up to 2 meters. Water sampling may be conducted in concert with in-situ monitoring rather than collecting samples from the flow-through hose. Such a change may reduce direct comparisons between field instrument and laboratory verifications, but the data is still expected to meet mission requirements. • A water-column monitoring team composed of at least one trained technician and a support person is deployed on a suitable platform. • The field team should record the time, instrument readings, and any relevant observations at selected time intervals. Global Positioning System (GPS) instruments are used to ascertain the exact position of each reading
F.5. Data Evaluation & Communication of Data/Results	SSC or designated representative.
F.6. Decontamination Equipment	instrument decontamination or send back to manufacturer for maintenance? follow recommended maintenance intervals. report all equipment malfunctions to group supervisor and response supervisor (RS). Fill out a DD-1149, REQUISITION AND INVOICE/SHIPPING DOCUMENT for property transfer.

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F.7. Data dump

Archiving note of data in case file

Look at note from Frank.

NOTE:

Per 40 C.F.R. 300.315, the FOSC is required to collect and maintain documentation of all actions taken under the Clean Water Act to support cost recovery, scientific understanding of the environment, and research and development. The FOSC is required to make available this documentation to trustees of affected natural resources.

In order to meet this requirement, SMART Monitoring teams shall save all dispersant monitoring data and provide electronic and/or hard copies to the following:

1. Incident Command Post Documentation Unit Leader

2. NSF Strike Team Case File

Section G: Tier III Monitoring Procedures

H.1. Introduction

Tiers I and II provide feedback to the Unified Command on the effectiveness of dispersant application. If dispersants are effective and additional information on the movement of the dispersed oil plume is desired, SMART Tier III procedures can address this need.

Tier III follows Tier II procedures, but collects information on the transport and dispersion of the oil in the water column. It helps to verify that the dispersed oil is diluting toward background levels. Tier III is simply an expanded monitoring role that is intended to meet the needs of the Unified Command.

H.2. Monitoring Operation

The following are steps in the monitoring observation of dispersants:

H.2.a. Multiple depths with one instrument

This monitoring technique provides a cross-section of relative concentrations of dispersed oil at different depths, measuring the dilution of dispersed oil down to background levels. When transecting the dispersant-treated slick (as outlined for Tier II) the team stops the vessel at location(s) where elevated readings are detected at 1 meter and, while holding position, the team monitors and collects samples at multiple

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increments down to a maximum depth of 10 meters. Readings are taken at each water depth, and the data recorded both automatically in the instrument data logger and manually by the monitors. Manual readings should be taken at discreet time intervals of 2 minutes, 5 minutes, etc. as specified by the Monitoring Group Supervisor or as indicated in a written sampling plan developed by the Dispersant Technical Specialist.

H.2.b. Transect at two different depths

This technique also looks at changes in concentration trends, but uses two monitoring instruments at different depths as the monitoring vessel transects the dispersed oil slick while making continuous observations. It is done as follows:

Monitoring is conducted at two different depths, 1 and 5 meters, or any two water depths agreed upon by the Incident Commander or the Unified Command. Two sampling setups and two separate monitoring instruments are used on a single vessel. The vessel transects the dispersant-treated slick as outlined in Tier II, except that now data are collected simultaneously for two water depths. While the data logger in each instrument automatically records the data separately, the monitoring team manually records the data from both instrument simultaneously at discrete time intervals of 2 minutes, 5 minutes, etc, as specified by the Monitoring Group Supervisor or the sampling plan developed by the Dispersant Technical Specialist. Comparison of the readings at the two water depths may provide information on the dilution trend of the dispersed oil.

H.2.c. Water parameters

In addition to instrument data, the Unified Command may request that water physical and chemical parameters be measured. This can be done by using a portable lab connected in-line with the instrument to measure water temperature, conductivity, dissolved oxygen content, pH, and turbidity. These data can help explain the behavior of the dispersed oil. The turbidity data may provide additional information on increased concentrations of dispersed oil if turbidity is elevated. The other physical and chemical parameters measure the characteristics of the water column that could possibly affect the rate of dispersion.

H.3.

Calibration and documentation used for Tier II are valid for Tier III as well, including the use of a check standard to verify instrument response. Because of the increased complexity of Tier III, a dispersant technical specialist (e.g., member of the scientific support team) should be on location to assist the monitoring efforts.

A critical point to keep in mind is that in the hectic and rapidly changing conditions of spill response, flexibility and adaptability are essential for success. The sampling plan is dictated by many factors such as the availability of equipment and personnel, on-scene conditions, and the

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window of opportunity for dispersant application. The need for flexibility in sampling design, effort, and rapid deployment (possibly using a vessel of opportunity), may dictate the nature and extent of the monitoring. To assist the monitoring efforts, it is important that the unified command agrees on the goals and objectives of monitoring and chooses the Tier or combination thereof to meet the needs of the response.

H.4. Preparation and Pre-Response Procedures

Ensure that there is a dedicated CG or contracted vessel for the duration of SMART monitoring. Coordinate through the Unified Command. CG-213RR? Follow equipment Job Aid for Tier II/III monitoring.

See equipment list in Chapter 5.

Under ideal circumstances, the team collects data in three primary target locations: (1) background water (no oil); (2) oiled surface slicks prior to dispersant application and (3) post-application, after the oil has been treated with dispersants.

Additional personnel required for Tier III is nice to have but not required.

Identify laboratory, refrigeration requirements, hazmat regulations for sending sampling, trucking company name (would take it directly to lab at LSU), Establish a change of custody for sampling.

H.5. Monitoring Procedures

H.5.a. Sample Management

H.6. Data Evaluation

H.7. Communication of Data/Results

H.8. Post Response Operations

H.9. Sample Management

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Section I: Atypical Dispersant Monitoring (Jesse will reduce)

I.1. Introduction

The Environmental Monitoring for Atypical Dispersant Operations provides a resource for the Regional Response Team (RRT), per 40 CFR 300.910 of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), when considering the atypical use of dispersants before and during an oil discharge. This document, developed by National Response Team (NRT) member agency representatives, is intended for use when responding to oil discharges and for RRT development of Regional Contingency Plans and expedited decision making addressing dispersant use of this nature.

The data generated by the measures below are meant for use as an operational response decision-making tool and not as a part of the long-term Natural Resources Damage Assessment (NRDA) data gathering efforts that may apply to the dispersant operation or other parts of the response. However, all of the data collected as a function of the guidance may be made available to NRDA personnel as soon as practicable.

While this document does not recommend specific cut-off points for dispersant applications (e.g., based on quantity of oil, amount of dispersant applied, duration of application), it does recommend "key indicators" the Federal On-Scene Coordinator (FOSC), and other decision makers should consider during dispersant monitoring and application activities. These key indicators should be revisited repeatedly throughout the incident to help determine whether and when dispersants should be applied or continue to be applied. Actions taken based on key indicator data should also consider the resource tradeoffs associated with dispersant use.

NOTE: **The Environmental Monitoring for Atypical Dispersant Operations guide provides guidance for two categories of atypical dispersant applications:**

1. Subsea Application: Generally applies to the subsurface ocean environment, focusing particularly on operations in waters below 300 meters and below the average pycnocline.

2. Prolonged Surface Application: supplements and complements the existing SMART program protocols where the duration of the application of dispersants on discharged oil extends beyond 96 hours from the time of first application

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I.2. Subsea Application Monitoring

Subsea application monitoring is beyond the scope and capabilities of the National Strike Force.

I.3. Prolonged Surface Application Monitoring

This guidance assumes that SMART protocols will be used for initial confirmation of dispersant effectiveness and deployed at the earliest time practicable for response conditions. The prolonged surface application guidance is intended to supplement and not replace SMART protocols.

NSF SMART Monitoring personnel can support prolonged surface application monitoring with similar TTPs for Tier I-III SMART dispersant monitoring.

Specific monitoring procedures for prolonged surface applications of dispersants will be established by the FOSC, SSC, and Unified Command based on the incident-specific needs.

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6)
SMART Equipment List

Introduction

This chapter discusses TTP discussed here is focused on the equipment used in in-situ burning or dispersant monitoring, since it is the current system being used by the NSF. These discussions and learning points do not prohibit the use of new technology or improved systems. Refer to Section D: Equipment for item descriptions and capabilities.

In This Chapter

This chapter contains the following sections:

Section	Title	Page
A	Particulate Air Monitor	5-2
B	Turner C3 Fluorometer	5-4
C	Water Parameter Measurement	5-8
D	Water Sampling	5-10
E	Digital Camera	5-11
F	Non-standard Laptop	5-13
G	Oil Drift Tracker	5-15
H	Communication	5-16
I	Vessel	5-18
J	Aircraft	5-20

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Section A: Particulate Air Monitor

A.1. Capabilities

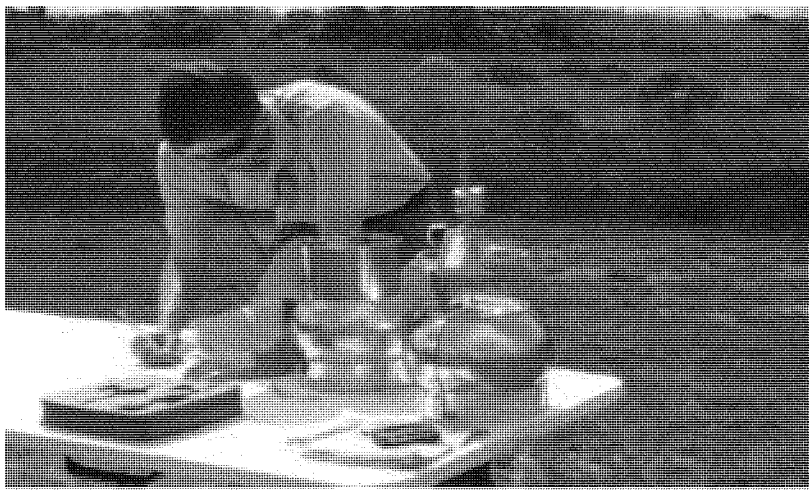

Figure 5-1. Air Monitoring

While conducting In-situ burning the NSF will deploy air monitoring teams when there is a concern that the general public may be exposed to smoke from the burning of oil. Each team should utilize a real-time particulate monitor capable of detecting the small particulates (ten microns in diameter or smaller) generated by the burn. Each monitoring instrument should display and log the instantaneous particulate concentration, as well as a time weighted average (TWA) concentration. SMART recommends measuring TWA concentrations averaged over a one-hour period.

A.2. Checklist

TSI Dustrack

USER MANUALS

SPARE CARTRIDGE, TYPE H

OMNI-DIRECTIONAL SAMPLER

CYCLONE PRECOLLECTOR

RS 232 COMPUTER INTERFACE CABLE

BATTERY CHARGER

ALLEN WRENCH, 3/32”

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LOG BOOK

TEMPERATURE CONDITIONING

HEATER

PM-10 INLET HEAD

(ANALYTICAL FILTER HOLDER)

STANDARD FILTER CARTRIDGES

DR4 SOFTWARE CD

INSTRUCTIONS FOR

PM-10 INLET HEAD

A.3. Specifications

Specific instruction. Threshold of hazardous particulates <10µM. maybe address troubleshooting guide in manual?

In Appendix C is typical data from Air Monitoring Log

There are monitors that monitor more than particulate size. The SMART program does not include the monitoring of other parameters. The FOSC may require the monitoring of other types of factors.

NOTE: **The Level of Concern (LOC) for SMART operations follows the National Response Team (NRT) guidelines. As of March 1999, the NRT recommends a conservative upper limit of 150 micrograms of PM-10 per cubic meter of air, averaged over one hour. This is the minimum standard and FOSC can establish incident specific criteria.**

NOTE: **The Unified Command must determine early on in the response what conditions, in addition to the LOC, justify termination of a burn or other action to protect public health. The Unified Command should work closely with local Public Health organizations in determining burn termination thresholds.**

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Section B: Turner C3 Fluorometer

C.1. Capabilities It is necessary to have both the Turner Designs C3 Submersible Fluorometer and the Instrumentation package.

interested in monitoring natural waters for the presence of Hydrocarbons, can use a C3 Submersible Fluorometer in a stand-alone configuration or with a mapping system such as ArcGIS.

Figure 5-2 Turner C3 Fluorometer Assembly setup operations

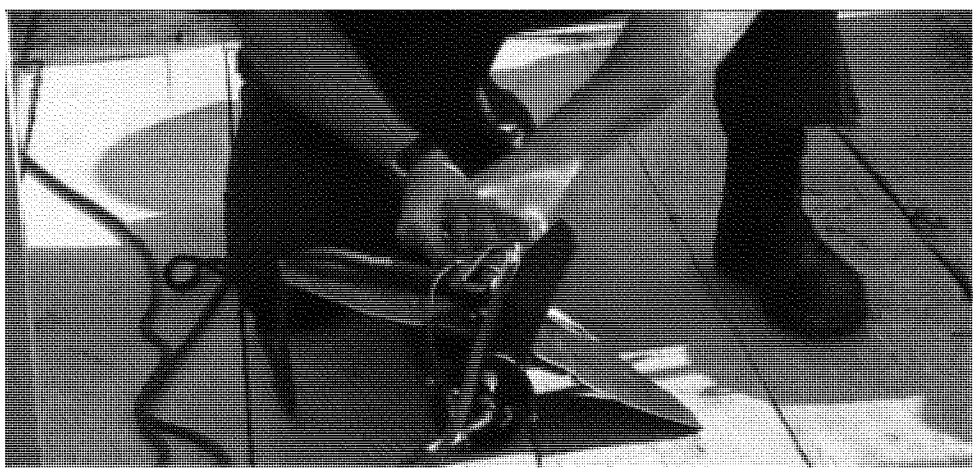

Figure 5-3 Turner C3 Fluorometer

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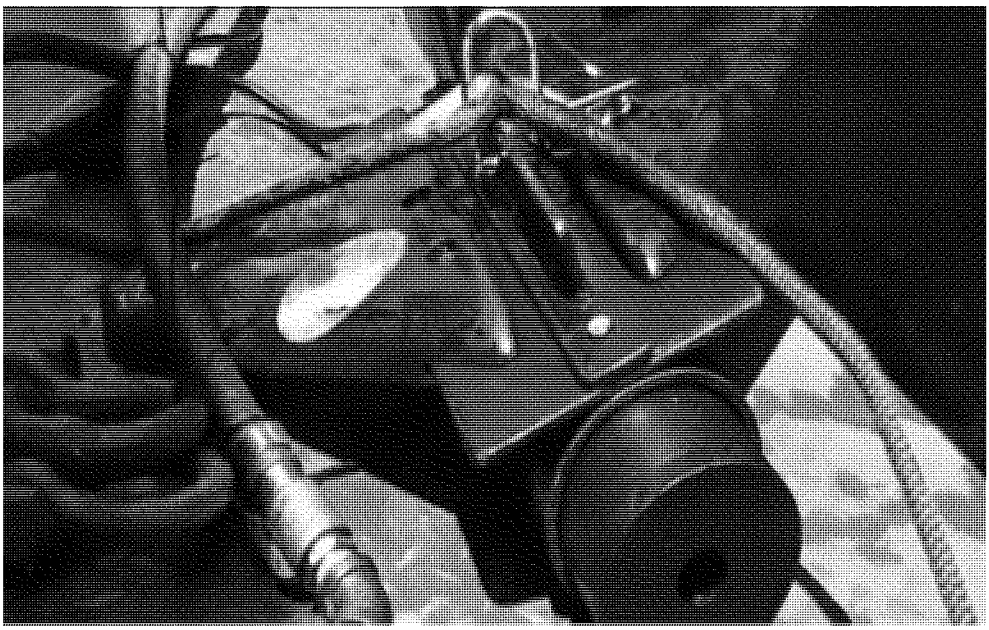

Figure 5-4 Turner C3 Fluorometer Assembly setup operations

GULF OF MEXICO – A U.S. Coast Guard Petty Officer lowers a fluorometer into the Gulf of Mexico. The instrument collects water samples and data to help determine the effectiveness of dispersants in breaking down the oil. Photo courtesy of U.S. Coast Guard

Figure 5-5. Fluorometer Instrument Collects Operations

C.2. Checklist

C3 Fluorometer (in towable body w/ Fins)

Shade Cap

Boosters (2)

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75' Data Cable

Toughbook & Power Supply Cable

120v Fluorometer Power Supple

C-3 Interface Cable

12v Adapter Plug for C-3

12v Adapter Laptop

Ronstan Wide Shackles 3/8" (3 EA)

SS Clevis Pins 3/8 X 1" (4 EA)

SS Anchor Shackles 3/8"

¼ X 20 X ½ Hex Head Bolts

Dual Outlet

Logitech V100 Mouse

Tool Kit (nut driver & screw driver)

12v Outlet with Clips

Battery Adapter 60" Cord

3/8 Double Braided Line w/ thimble 75'

Dye Rhodamin

Zip Ties (Bag)

Alcohol Wipes

Software Disks

Blank CD-R Disks (4 EA)

Manuals and SMART (six part folder)

Log Book

Section D: Water Parameter Measurement

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E.1. Capabilities

E.2. Checklist

DS5 MULTI PROBE WITH CONNECTOR COVER

SURVEYOR

CALIBRATION CAP

POWER CORD AND INTERNATIONAL ADAPTERS

WEIGHTED SENSOR GUARD

HYDRAS 3 LT SOFTWARE CD

CR-2032 BATTERIES

INSTRUCTION SHEET FOR THE SELF CLEANING TURBIDITY SENSOR

INSTRUCTION SHEET FOR LDO SENSOR

SURVEYOR MANUAL

HYDROLAB DS5 MANUAL

HYDRAS 3 LT MANUAL

50-FOOT CABLE WITH CONNECTOR COVER

4 PIN SERIAL CABLE

9 PIN SERIAL CABLE

TURBIDITY KIT: ALLEN WRENCH, (4) WIPER BLADES W/SET SCREWS (2)

SILICONE COMPOUND

(4) 80mm O RINGS

(4) 20mm O RINGS

MSDS SHEETS

TEFLON JUNCTION, PN 000548HY

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KCl SALT PELLETS, PN 005376HY

pH REFERENCE ELECTRODE SATURATED KCl AND AgCl

INSTRUCTION SHEET FOR pH SALT PELLETS

E.3. Hydrolab

Figure 5-6. Hydrolab

Figure 5-7 Hydrolab sampling operations

Hydrolab & sampling needs to be figured out. See R&D gap document

E.4.

Section F: Water Sampling

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F.1. Capabilities

Figure 5-8. Water Sample Collections and data operations

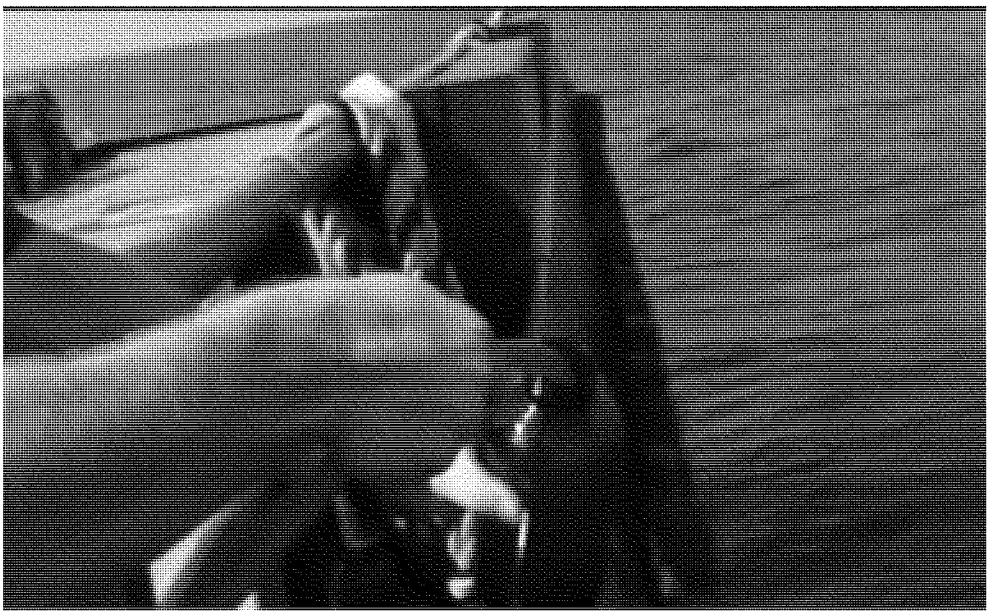

Figure 5-9. SMART Equipment assembly

F.2. Checklist

Need to check R&D report for some better equipment

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Section G: Digital Camera

G.1. Capabilities

Per Dave Studer: A web site we may want to look at for cameras and photo mapping: http://www.geotacticalsolutions.com/

ruggedized, GPS, wireless, video, water-resistant

per Jesse Harms, LT Trevor Blount is researching NSF Digital Cameras that are in the current inventory. The GST has 8 cameras that meet this capability requirement. The other Teams should, he is looking into it. We should build a TTP for camera use within this section, especially if we determine that the current camera is a viable option for the next 3-5 years.

Per Tim Bowlin, Photo-Website:

The Defense Video & Imagery Distribution System. The field observers will upload their photos/imagery to this site, or other incident determined photo cache location online. This will require establishment of accounts by potential field observers prior to deployment.

All images should only be uploaded to the private section of a site (s) to prevent unauthorized distribution of material publicly.

https://www.dvidshub.net/unit/USCGHQ

Figure 5-10 dvids website

Strike Team's (AST, GST, & PST) Set-up accounts, and work with District's P/A for uploading/processing - SMART - photo's...

G.2. Checklist

Garmin Monterra camera, part number: 010-01065-00

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G.3. Garmin Monterra

test

Figure 5-11. Garmin Monterra Unit

NOTE: **Personnel should use government issued cameras due to possible confiscation for use as evidence.**

G.4.

G.5.

G.6.

G.7.

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Section H: Non-standard Laptop

H.1. Capabilities

A non- standard laptop computer system is needed to assist team members responding to oil spills, uploading/collating/forwarding data from SMART equipment to the SSC and environmental unit for analyze. This information is used to make decisions in the application of alternative cleanup methods.

These laptops use off-the-shelf software and SMART equipment software that is often not compatible with USCG firewalls.

H.2. Requirements and Software

Non-Standard Laptop (Trevor will check on SMART software requirements)

a. Windows OS
b. Microsoft Office
c. Adobe Acrobat
d. Anti-virus
e. Wizer
f. Software for SMART equipment (ensure it is compatible with OS)
g. Writable DVD/BD drive (could be external)
h. WiFi
i. Blue Tooth
j. Adapters for equipment to computer

6. Mouse
7. Portable printer
8. Encrypted Hard drive
9. Power inverter for auto/aircraft
10. Hot-Spot from Wireless carrier
11. Misc. consumables e.g. printer paper, printer ink, cables, writable DVD/BD discs, SD cards

NOTE: **Non-standard laptops are typically used during In-Situ monitoring as the required software is not generally compatible with USCG firewalls.**

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Figure 5-12 SMART Laptop Data Collections

Figure 5-13 SMART Disassembly equipment operations

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Section I: Oil Drift Tracker

J.1. Capability	
J.2. Existing Equipment	Self-locating datum marking buoy
J.3. MetOcean Buoy – surface slicks	iSPHERE Drift Calculation GSA website https://www.gsaadvantage.gov/advantage/s/search.do?q=0:2iSPHERE-SP&db=0&searchType=0 Iridium satellite service, JouBeh Technologies, recommended by Emily MacPherson at MetOcean www.joubeh.com Per Ed, the buoy may not stay with oil after several days (or a few hours) but that might be okay. Oil slicks as we know, sit at the interface between air and water. iSpheres were designed to be influenced by wind, Stokes drift and currents, i.e. to behave as much as is possible like oil spills. They sit in the water with 50% above and below the water line. Merv Fingas from Interspill about Environment Canada's testing- Doesn't believe iSPHERE functions the same a SLDMB
J.4. Self-Locating Datum Buoy (SLDMB) – dispersed oil droplets	Already in the CG inventory, this buoy is designed to resemble the drift exhibited by a person in the water and was created to support Coast Guard Search and Rescue efforts. SLDMB are CODE or "Davis style drifter" which are designed to measure the top meter (or 0.5m) of the water column and have the direct influence of the wind minimized. They generally only have a few Styrofoam floats and an antenna which protrudes above the water line, minimizing windage. They are used widely in oceanographer to measure "surface" currents -- with surface defined as the top meter. To track dispersed oil droplets, the SLDMBs may be more effective than iSpheres. May not track oil but does give information about near surface currents.

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Section K: Communication

L.1. Introduction

Figure 5-15 SMART Team Data Collection operations

Satellite communication, air to ground, air to vessel, vessel to ICP, aircraft to ICP,

L.2. Capabilities

L.3. Checklist

L.4. Briefing

Figure 5-16 SMART Team briefing operations

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Section M: Vessel

M.1. Capabilities

Any boat will suffice as a platform for conducting SMART protocols for monitoring dispersant operations as long as it can accommodate at least two passengers in addition to the required crew because it is a relatively small, hand carried piece of equipment. Minimal deck space is required for set up/deployment (recommend at least 25 sqft). Even though the fluorometry kit is a self-sufficient package there are, however, certain vessel characteristics that would be beneficial (see below). If necessary, the NSF can provide a vessel that is appropriate for the circumstance. There should be a plan for decontamination of vessel.

The Operations Section Chief should decide on the appropriate vessel based on such considerations as distance offshore, duration of deployment, weather, etc. The Strike Teams have two standardized 26' TANB's and three skiffs that may be used or a more appropriate vessel can be procured. For example an offshore SMART response recommend offshore supply vessel with adequate crew space for team rest/comfort. Recommend 100 square foot minimum deck space for flourometer setup and use. Ability or room to install antenna for air frequency radio is essential for communications with dispersant spotter aircraft.

M.2. Examples of Vessels

- Trailerable Aids to Navigation Boat (TANB)
- 18 foot Jon boat
- Vessel of Opportunity (VOO)

M.3. Beneficial Characteristics

A/C plug in: system comes with a battery, but a built in power source provides a back-up and long term sustainability.

David: allows the monitor to be lowered into the water away from the side of the vessel minimizing chance of it being affected by or interfering with the screw.

Navigation package compatible to CG SINS package: to input/establish waypoints, transit pre-determined routes, etc.

Weather monitoring equipment: to attain air/water temperature, wind speed and direction.

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	Internet or other ability to transmit results. Communication: Radio, satellite phone.
M.4. Comforts for long term monitoring	Cabin to escape the weather Galley Head
M.5. Vessel Decontamination Process	Vessels will be decontaminated as per the decontamination plan within the Site Safety Plan

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Section N: Aircraft

N.1. Introduction

While in the short term, Coast Guard aircrafts are used. In the long term, contracted aircrafts are typically used.

N.2. Capabilities

Operational Requirements for oil spill response aircrafts (CGMER might have this information). May reference aerial spotting training syllabus (ask NOAA).

N.3. Long Range Surveillance (LRS) Aircrafts

The Coast Guard's LRS capability and provisions for heavy air transport include, but are not limited to Coast Guard Maritime Safety & Security Teams (MSSTs), Port Security Units (PSUs), and National Strike Force (NSF) movements.

N.3.a. HC-130H Hercules

Figure 5-17. HC-130H Hercules

Current HC-130H inventory is 22. The HC-130H's range and average speed is 3500 NM and 280 knots. Its maximum endurance is 14.5 hours, climate conditions permitting.

The HC-130H aircraft maintains the capability for aerial delivery of dispersant through the Aerial Delivery Dispersant System (ADDS) at Air Stations Barbers Point, HI and Kodiak, AK.

HC-130H Sensors: Multimode surface search radar; Wescam MX-20 EO/IR; APS-125 weather radar; DF-430 UHF/VHF Direction Finder System; AIS, VHF/FM, UHF/AM, HF, MILSATCOM, Rescue 21 radios, IRIDIUM.

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N.3.b. HC-130J

Figure 5-18. HC-130J Super Hercules

The HC-130J Super Hercules inventory is six, all of which had become operational by late 2008. LRS aircraft have the capability to capture and record images and video with its sensor system suite and are all Night Vision Goggle (NVG) capable. Range and average speed for the HC-130J is 4900 NM with an average speed of 320 knots. Its maximum endurance is rated for 20 hours, climate conditions permitting.

HC-130J Sensors: Multimode (SAR/ISAR/Search) surface search radar; APN-241 low power weather radar; Electro-Optical/Infrared (EO/IR) FLIR Systems Star Safire III; DF-430 UHF/VHF Direction Finder System; Airborne Automatic Identification System (AIS); VHF/FM, UHF/AM, HF, MILSATCOM, Rescue 21 radios, INMARSAT.

N.4. Medium Range Surveillance (MRS) Aircrafts

The MRS aircraft inventory, consisting of 18 HC-144A and 14 HC-27J, are for medium range air transport, to include, but are not limited to MSST, PSU, and NSF movements. Roles include SAR, law enforcement, and environmental protection.

N.4.a. HC-144A
The Ocean Sentry

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Figure 5-19 HC-144A

HC-144A is manufactured by CASA. The HC-144A has the capability to capture and record images and video with its sensor system suite. The HC-144A airframe is NVG capable. The HC-144's range and average speed is 2100 NM and 215 knots. Its maximum endurance is 10.5 hours, climate conditions permitting.

HC-144A Sensors: Multimode surface search radar; EO/IR -FLIR Systems Star Safire III; AIS; DF-430 UHF/VHF Direction Finder System; VHF/FM, UHF/AM, HF, MILSATCOM, INMARSAT, Rescue 21 radios.

N.4.b. HC-27J

Figure 5-20 HC-27J

HC-27J is manufactured by Alenia and Lockheed Martin. The HC-27J aircraft are undergoing its implementation phase by the Asset Project Office out of Elizabeth City, NC. Anticipated time for integration to Coast Guard operations is from 2016 – 2018. The HC-27J airframe is NVG capable. Range and average speed for the HC-27J is 2675 NM and 290

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knots. Its maximum endurance is 12 hours, climate conditions permitting.

HC-27J: Aircraft currently has the APN-241 low power weather radar, capable of ground mapping, with limited surface detection. Currently not configured with tradition sensor system suites. VHF/FM, UHF/AM, HF, MILSATCOM, INMARSAT, Rescue 21 radios

---

N.5. Medium Range Recovery (MRR) Aircraft: MH-60 J/T Jayhawk

Figure 5-21. MH-60 Jayhawk

The MH-60 Jayhawk is a twin-engine, single-rotor aircraft that serves as the Coast Guard's MRR Helicopter. There are 35 MH-60s in the fleet today, comprising nearly 30 percent of all Coast Guard helicopters. These aircraft support the Coast Guard across the Inland, Coastal, and Offshore zones. The aircraft is capable of in-flight refueling (HIFR) from major cutters. The MH-60 can land on some, but cannot be hangered on Coast Guard assets.

Jayhawks have a maximum range of 700 NM and can sprint at speeds up to 180 knots. They have six-hour endurance. It is all-weather, day and night capable with night capabilities enhanced through the use of NVGs by the pilots and aircrew. The hoist system on the MH-60 is rated to 600 pounds. They are capable of providing limited first aid to rescued persons.

MH-60T Capabilities: VHF/UHF AM, VHF-FM, HF/ALE, DF/ADF, MILSATCOM (voice/data), Rescue 21 radios and the Search/Weather Radar.

The MH-60 lacks a data link or SATCOM equipment, constraining its ability to communicate with other Coast Guard, DHS, and DOD assets.

N.6. Short Range

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Recovery (SRR) Aircraft: MH-65 Dolphin

Figure 5-22 MH-65 Dolphin

The MH-65 Dolphin is the Coast Guard's SRR helicopter. It is an all-weather twin-engine, single rotor aircraft with a crew of four that performs and supports all Coast Guard missions in the inland, coastal, and offshore zones. There are currently 88 MH-65s operational, which account for 70 percent of the Coast Guard rotary-wing fleet.

The MH-65 is most suited as an aviation prosecution asset while operating either from land or the Coast Guard's medium and high endurance cutters. The Dolphin's endurance is 3.5 hours at a speed of 75 knots. It can sprint at speeds up to 175 knots and sustain speeds of over 140 knots.

MH-65s are limited in fuel capacity and power, which requires pilots to make constant trade-offs between speed, endurance, and number of crew. Their limited endurance and radius of action give them limited effectiveness for land-based operations. The weather radar may be used for larger target searches, but is less effective for locating small targets.

MH-65D Capabilities: VHF/UHF AM, VHF-FM, HF/ALE, Search/ Weather Radar (can be used to detect oil sheens through ground mapping), DF/ADF, MILSATCOM (voice/data), and Rescue 21 radios. Fully NVG compatible and equipped with a Heads Up Display (HUD). The EO/IR turret provides infrared detection and low-light optical reconnaissance and search capability.

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7) Safety

Introduction

This chapter is focused on SMART Responder Safety. Under the National Contingency Plan, worker health and safety are paramount concerns and the FOSC and RP are responsible for addressing these issues. Additionally, all response actions must comply with OSHA training and safety requirements.

In This Chapter

This chapter contains the following sections:

Section	Title	Page
A	Introduction	6-2
B	Protecting SMART Responders	6-4
C	Proper PPE	6-5
D	Weather and Sea Conditions	6-6
E	Safety & Smoke Plumes	6-7
F	SMART Responder Logistics	6-8

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Section A: Introduction

A.1. The FOSC is responsible for ensuring that health and safety requirements are adequately addressed during a response. Individuals should not engage in activities that they are not appropriately trained or currently qualified to perform. Individuals are expected to adhere to safety procedures appropriate to the conditions they are working under and/or are included in a dispersant-specific Site Safety Plan Annex. Vessel/aircraft operators are expected to define appropriate operational limits and safety and maintenance requirements for their craft. Vessels and response resources should be properly maintained and undergo proper decontamination procedures. Apply dispersants only if there is no significant risk to response personnel (e.g., ignition risk, operational hazards). Ensure the appropriate personal protective equipment (PPE) is available. Ensure that application aircraft and vessels remain within standard operating limits. Each person involved in a response is required to take personal responsibility for his or her safety. The FOSC may appoint a Safety Officer and request development of a specific Site Safety Plan Annex. Key safety aspects to be considered in the plan may include:

- Physical hazards (e.g., waves, tides, unstable or slippery surfaces)
- Heavy machinery and equipment
- Chemical hazards (e.g., oil and dispersant exposure)
- Atmospheric hazards (e.g., fumes, ignition risks)
- Confined spaces
- PPE
- Noise
- Fatigue
- Heat/cold stress
- Wildlife (bites/stings)
- Cleanup facilities
- Medical treatment

A.2. Edward Bock: If truly necessary, the CG Executive Secretariat to the NRT, Ms. Monica Maghini, may be able to identify a representative, reach out through LT Kulesa. I suggest that a qualified Health and Safety professional from the HSWL can provide a summary of dispersant health hazards. Possibly consider consulting a NSF IH as well, possibly Ed

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Primeau. I help with participation.

A.3. Example of Safety Data Sheet -

A.4.

A.5.

A.6.

A.7.

A.8.

A.9.

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Section B: Protecting SMART Responders

B.1.

B.2.

B.3.

B.4.

B.5.

B.6.

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B.8.

B.9.

B.10.

B.11.

B.12.

B.13.

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Section C: Proper PPE

C.1.

C.2.

C.3.

C.4.

C.5.

C.6.

C.7.

C.8.

C.9.

C.10.

C.11.

C.12.

C.13.

C.14.

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Section D: Weather and Sea Conditions

D.1. SMART may not be possible due to adverse weather all of which contributed to concerns about whether to proceed with sub-sea dispersant application…

D.2.

D.3.

D.4.

D.5.

D.6.

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D.9.

D.10.

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D.12.

D.13.

D.14.

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Section E: Safety & Smoke Plumes

E.1. A marine In-Situ burn safety plan can be found in this link:

http://response.restoration.noaa.gov/sites/default/files/NAVY_sample_site_safety_ISB.pdf

E.2.

E.3.

E.4.

E.5.

E.6.

E.7.

E.8.

E.9.

E.10.

E.11.

E.12.

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Section F: SMART Responder Logistics

F.1.

F.2.

F.3.

F.4.

F.5.

F.6.

F.7.

F.8.

F.9.

F.10.

F.11.

F.12.

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F.14.

F.15.

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7)
Glossary and Acronyms

µg/L	Micrograms per liter
AIS	Automatic Identification System.
ASTM	American Society for Testing and Materials
CDC	Center for Disease Control
COTP	Captain of the port
CSNCOE	Cruise Ship National Center of Expertise
CSR	Continuous Synopsis Record.
CVSSA	Cruise Vessel Security and Safety Act
DWH	Deep Water Horizon
EPA	Environmental Protection Agency
EPIRB	Emergency Position Indicating Radio Beacon
ETA	Estimated time of arrival
FOSC	Federal On Scene Coordinator
Hydrocarbon based spills	Hydrocarbons are a class of chemicals that contain only hydrogen and carbon atoms. Some have hydrogen with rings of carbon atoms, called polycyclic aromatic hydrocarbons (PAHs). Hydrocarbons with additives, such as gasoline, also are included. Typical substances include automotive gasoline, benzene, butadiene, fuel oils, jet fuels, and various PAHs. PAHs include naphthylene and over 100 different substances formed during the incomplete burning of coal, oil and gas, garbage, or other organic substances like tobacco or charbroiled meat. PAHs are found in coal tar, crude oil, creosote, and roofing tar, but a few are used in medicines or to make dyes, plastics, and pesticides. This list is not all inclusive.

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ICS	Incident Command System
INMARSAT	International Maritime Satellite
ISAR	Inverse Synthetic Aperture Radar
kJ	Kilojoule
LOC	Level of Concern
LRIT	Long range identification and tracking.
MARPOL	International Convention for the Prevention of Pollution from Ships
MARSEC	Maritime Security
MGS	Monitoring Group Supervisor
MISLE	Marine Information for Safety and Law Enforcement
MMSI	Maritime Mobile Service Identity
NIOSH	National Institute for Occupational Safety and Health
NSF	National Strike Force
OCM	Oily content meter.
OCMI	Officer in charge, marine inspections
OR&R	Office of Response and Restoration
PERC	Perchloroethylene
POB	Persons on board.
PPE	Personnel protection equipment.
RM	Response Member. This is the entry level of qualification for all NSF personnel. All personnel are expected to earn this qualification within 4

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	months of reporting. An RM is considered a "journeyman" with the basic hazardous materials and oil spill knowledge to identify all Strike Team equipment and its intended use. He/she may have technical skill sets from previous units including machinery, seamanship, marine safety, and shipboard damage control.
SAR	Synthetic Aperture Radar
SAR	Search and rescue
SMART	Special Monitoring of Applied Response Technologies
SSC	Scientific Support Coordinators
TTP	Tactics, techniques, and procedures.
UC	Unified Command
USPHS	U.S. Public Health Service
VDR	Voyage data recorder

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7)
Example of Safety Data Sheet

B.1.

NALCO
Environmental Solutions LLC

SAFETY DATA SHEET

PRODUCT

COREXIT® EC9527A

EMERGENCY TELEPHONE NUMBER(S)
(800) 424-9300 (24 Hours) CHEMTREC

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

PRODUCT NAME :	**COREXIT® EC9527A**
APPLICATION :	OIL SPILL DISPERSANT
COMPANY IDENTIFICATION :	Nalco Environmental Solutions LLC 7705 Highway 90-A Sugar Land, Texas 77478
EMERGENCY TELEPHONE NUMBER(S) :	(800) 424-9300 (24 Hours) CHEMTREC

NFPA 704M/HMIS RATING
HEALTH : 2 / 2* FLAMMABILITY : 1 / 1 INSTABILITY : 0 / 0 OTHER :
0 = Insignificant 1 = Slight 2 = Moderate 3 = High 4 = Extreme * = Chronic Health Hazard

2. COMPOSITION/INFORMATION ON INGREDIENTS

Our hazard evaluation has identified the following chemical substance(s) as hazardous. Consult Section 15 for the nature of the hazard(s).

Hazardous Substance(s)	CAS NO	% (w/w)
2-Butoxyethanol	111-76-2	30.0 - 60.0
Organic sulfonic acid salt	Proprietary	10.0 - 30.0
Propylene Glycol	57-55-6	1.0 - 5.0

3. HAZARDS IDENTIFICATION

****EMERGENCY OVERVIEW****

WARNING
Can be an eye and skin irritant. Repeated or excessive exposure to butoxyethanol may cause injury to red blood cells (hemolysis), kidney or the liver. Harmful by inhalation, in contact with skin or if swallowed.
Do not get in eyes, on skin or on clothing. Do not take internally. Use with adequate ventilation. Wear suitable protective clothing. Keep container tightly closed. Flush affected area with water. Keep away from heat. Keep away from sources of ignition - No smoking.
May evolve oxides of carbon (COx) under fire conditions.

PRIMARY ROUTES OF EXPOSURE :
Eye, Skin

HUMAN HEALTH HAZARDS - ACUTE :

EYE CONTACT :
Can cause irritation.

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SKIN CONTACT :
Can cause moderate irritation. Harmful if absorbed through skin.

INGESTION :
May be harmful if swallowed. May cause liver and kidney effects and/or damage. There may be irritation to the gastro-intestinal tract.

INHALATION :
Harmful by inhalation. Repeated or prolonged exposure may irritate the respiratory tract.

SYMPTOMS OF EXPOSURE :
Acute :
Excessive exposure may cause central nervous system effects, nausea, vomiting, anesthetic or narcotic effects.
Chronic :
Repeated or excessive exposure to butoxyethanol may cause injury to red blood cells (hemolysis), kidney or the liver.

AGGRAVATION OF EXISTING CONDITIONS :
Skin contact may aggravate an existing dermatitis condition.

HUMAN HEALTH HAZARDS - CHRONIC :
Contains ethylene glycol monobutyl ether (butoxyethanol). Prolonged and/or repeated exposure through inhalation or extensive skin contact with EGBE may result in damage to the blood and kidneys.

4. FIRST AID MEASURES

EYE CONTACT :
Flush affected area with water. Get medical attention.

SKIN CONTACT :
Flush affected area with water. Get medical attention.

INGESTION :
Do not induce vomiting without medical advice. If conscious, washout mouth and give water to drink. Get medical attention.

INHALATION :
Remove to fresh air, treat symptomatically. If symptoms develop, seek medical advice.

NOTE TO PHYSICIAN :
Based on the individual reactions of the patient, the physician's judgement should be used to control symptoms and clinical condition.

5. FIRE FIGHTING MEASURES

FLASH POINT : 163 °F / 72.7 °C (TCC)

This product does not sustain combustion per the method outlined in 49 CFR Appendix H.

EXTINGUISHING MEDIA :
This product would not be expected to burn unless all the water is boiled away. The remaining organics may be ignitable. Use extinguishing media appropriate for surrounding fire.

FIRE AND EXPLOSION HAZARD :
May evolve oxides of carbon (COx) under fire conditions.

SPECIAL PROTECTIVE EQUIPMENT FOR FIRE FIGHTING :
In case of fire, wear a full face positive-pressure self contained breathing apparatus and protective suit.

6. ACCIDENTAL RELEASE MEASURES

PERSONAL PRECAUTIONS :
Restrict access to area as appropriate until clean-up operations are complete. Stop or reduce any leaks if it is safe to do so. Do not touch spilled material. Ventilate spill area if possible. Use personal protective equipment recommended in Section 8 (Exposure Controls/Personal Protection).

METHODS FOR CLEANING UP :
SMALL SPILLS: Soak up spill with absorbent material. Place residues in a suitable, covered, properly labeled container. Wash affected area. LARGE SPILLS: Contain liquid using absorbent material, by digging trenches or by diking. Reclaim into recovery or salvage drums or tank truck for proper disposal. Contact an approved waste hauler for disposal of contaminated recovered material. Dispose of material in compliance with regulations indicated in Section 13 (Disposal Considerations).

ENVIRONMENTAL PRECAUTIONS :
Do not contaminate surface water.

7. HANDLING AND STORAGE

HANDLING :
Avoid eye and skin contact. Do not take internally. Ensure all containers are labeled. Keep the containers closed when not in use.

STORAGE CONDITIONS :
Store the containers tightly closed.

SUITABLE CONSTRUCTION MATERIAL :
Stainless Steel 316L, Hastelloy C-276, MDPE (medium density polyethylene), Nitrile, Plexiglass, TFE, HDPE (high density polyethylene), Neoprene, Aluminum, Polypropylene, Polyethylene, Carbon Steel C1018, Stainless Steel 304, FEP (encapsulated), Perfluoroelastomer, PVC, PTFE, Polytetrafluoroethylene/polypropylene copolymer.
Compatibility with Plastic Materials can vary; we therefore recommend that compatibility is tested prior to use.

UNSUITABLE CONSTRUCTION MATERIAL :
Copper, Mild steel, Brass, Nylon, Buna-N, Natural rubber, Polyurethane, Ethylene propylene, EPDM, Fluoroelastomer, Chlorosulfonated polyethylene rubber

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SAFETY DATA SHEET

PRODUCT

COREXIT® EC9527A

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8. EXPOSURE CONTROLS/PERSONAL PROTECTION

OCCUPATIONAL EXPOSURE LIMITS :
Exposure guidelines have not been established for this product. Available exposure limits for the substance(s) are shown below.

Substance(s)	Category:	ppm	mg/m3	Non-Standard Unit
2-Butoxyethanol	ACGIH/TWA	20		
	OSHA Z1/PEL	50	240	
	OSHA Z1/Skin*			
Propylene Glycol (Aerosol.)	WEEL/TWA		10	

* Can be absorbed through the skin.

ENGINEERING MEASURES :
General ventilation is recommended.

RESPIRATORY PROTECTION :
Where concentrations in air may exceed the limits given in this section, the use of a half face filter mask or air supplied breathing apparatus is recommended. A suitable filter material depends on the amount and type of chemicals being handled. Consider the use of filter type: Multi-contaminant cartridge. with a Particulate pre-filter. In event of emergency or planned entry into unknown concentrations a positive pressure, full-facepiece SCBA should be used. If respiratory protection is required, institute a complete respiratory protection program including selection, fit testing, training, maintenance and inspection.

HAND PROTECTION :
Neoprene gloves Nitrile gloves Butyl gloves PVC gloves Breakthrough time not determined as preparation, consult PPE manufacturers.

SKIN PROTECTION :
Wear standard protective clothing.

EYE PROTECTION :
Wear chemical splash goggles.

HYGIENE RECOMMENDATIONS :
Use good work and personal hygiene practices to avoid exposure. Keep an eye wash fountain available. Keep a safety shower available. If clothing is contaminated, remove clothing and thoroughly wash the affected area. Launder contaminated clothing before reuse. Always wash thoroughly after handling chemicals. When handling this product never eat, drink or smoke.

HUMAN EXPOSURE CHARACTERIZATION :
Based on our recommended product application and personal protective equipment, the potential human exposure is: Low

NALCO Environmental Solutions LLC

SAFETY DATA SHEET

PRODUCT

COREXIT® EC9527A

EMERGENCY TELEPHONE NUMBER(S)
(800) 424-9300 (24 Hours) CHEMTREC

9. PHYSICAL AND CHEMICAL PROPERTIES

PHYSICAL STATE	Liquid
APPEARANCE	Clear Amber
ODOR	Mild

SPECIFIC GRAVITY	0.98 - 1.02
DENSITY	8.2 - 8.5 lb/gal
SOLUBILITY IN WATER	Complete
pH (100 %)	6.1
VISCOSITY	160 cst @ 32 °F / 0 °C
POUR POINT	ASTM D-97 -66.9 °F / -55 °C
POUR POINT	< -40 °F / < -40 °C
BOILING POINT	340 °F / 171 °C
VAPOR PRESSURE	< 5 mm Hg @ 100 °F / 38 °C Same as water
EVAPORATION RATE	0.1 (water=1)

Note: These physical properties are typical values for this product and are subject to change.

10. STABILITY AND REACTIVITY

STABILITY :
Stable under normal conditions.

HAZARDOUS POLYMERIZATION :
Hazardous polymerization will not occur.

CONDITIONS TO AVOID :
Extremes of temperature

MATERIALS TO AVOID :
Contact with strong oxidizers (e.g. chlorine, peroxides, chromates, nitric acid, perchlorate, concentrated oxygen, permanganate) may generate heat, fires, explosions and/or toxic vapors.

HAZARDOUS DECOMPOSITION PRODUCTS :
Under fire conditions: Oxides of carbon

11. TOXICOLOGICAL INFORMATION

The following toxicity information is for the product.

SENSITIZATION:
This product is not expected to be a sensitizer.

NALCO Environmental Solutions LLC

SAFETY DATA SHEET

PRODUCT

COREXIT® EC9527A

EMERGENCY TELEPHONE NUMBER(S)
(800) 424-9300 (24 Hours) CHEMTREC

CARCINOGENICITY:
None of the substances in this product are listed as carcinogens by the International Agency for Research on Cancer (IARC) or the National Toxicology Program (NTP). 2-Butoxyethanol is listed as an A3 carcinogen (confirmed animal carcinogen with unknown relevance to humans) by the American Conference of Governmental Industrial Hygienists (ACGIH). Upon further independent evaluation by IARC (2004) and IRIS (EPA Integrated Risk Information System) (2005) 2-butoxyethanol was found to be "not classifiable as to carcinogenicity to humans" and "not likely to be a human carcinogen", respectively.

HUMAN HAZARD CHARACTERIZATION:
Based on our hazard characterization, the potential human hazard is: High

---

TOXICOLOGICAL INFORMATION RELATED TO THE WHOLE PRODUCT AND ITS COMPONENTS:

Acute mammalian toxicity studies have been conducted under laboratory conditions that test the toxicity of the product following exposure that would not reflect those for humans under normal use situations. This information is provided below. Other information is also provided from third party sources related to the mammalian toxicity for the six components in the product.

ACUTE TOXICITY FOR THE PRODUCT MIXTURE:

ORAL (Rat): LD50 > 1,750 mg/kg

DERMAL (Rabbit): LD50 > 1,000 mg/kg

(Rat): LD50 > 2,000 mg/kg

DERMAL IRRITATION (Rabbit): Very mild irritant. No clinically significant effects beyond day 10 post-application.

INHALATION (Rat): LC50 < 2.08 mg/L

EYE IRRITATION(Rabbit): Moderate eye irritant, corneal opacity in 1/4 rabbits; all cornea, iris and conjunctival effects cleared in all rabbits by day 14.

ACUTE ORAL TOXICITY FOR THE COMPONENTS:

Component: Polyol ester
Species: Rat
LD50: > 16,000 mg/kg
Remarks: This data was sourced from the supplier MSDS.

Component: 2-Butoxyethanol
Species: Rat
LD50: 1,746 mg/kg
Remarks: This data was sourced from the supplier MSDS.

Component: 2-Butoxyethanol
Species: Guinea Pig
LD50: 1,400 mg/kg
Remarks: This data was sourced from the supplier MSDS.

Component: Oxyalkylated Fatty Acid Derivative
Species: Rat
LD50: > 38,000 mg/kg
Remarks: This data was sourced from the supplier MSDS.

Component: Oxyalkylate Polymer
Species: Rat
LD50: > 36,400 mg/kg
Remarks: This data was sourced from the supplier MSDS.

Component: Organic Sulfonic Acid Salt
Species: Rat
LD50: 4,620 mg/kg
Remarks: This data was sourced from an IUCLID Dataset searched on 6/2/2010.

Component: Propylene glycol
Species: Rat
LD50: 29,536 mg/kg
Remarks: This data was sourced from an IUCLID Dataset searched on 6/3/2010.

Component: Propylene glycol
Species: Mouse
LD50: 22,000 mg/kg
Remarks: This data was sourced from an IUCLID Dataset searched on 6/3/2010.

Component: Propylene glycol
Species: Rabbit
LD50: 18,500 mg/kg
Remarks: This data was sourced from an IUCLID Dataset searched on 6/3/2010.

Component: Propylene glycol
Species: Dog
LD50: 22,000 mg/kg
Remarks: This data was sourced from an IUCLID Dataset searched on 6/3/2010.

ACUTE DERMAL TOXICITY FOR THE COMPONENTS:

Component: 2-Butoxyethanol
Species: Guinea Pig
LD50: > 2,000 mg/kg
Remarks: This data was sourced from the supplier MSDS.

Component: 2-Butoxyethanol
Species: Rat
LD50: 2,210 mg/kg
Remarks: This data was sourced from the supplier MSDS.

Component: 2-Butoxyethanol
Species: Rabbit
LD50: 99 - 610 mg/kg
Remarks: This data was sourced from the supplier MSDS.

Component: Organic Sulfonic Acid Salt
Species: Rabbit
LD50: 10,000 mg/kg
Remarks: This data was sourced from an IUCLID Dataset searched on 6/2/2010.

Component: Propylene glycol
Species: Rabbit
LD50: 20,800 mg/kg
Remarks: This data was sourced from an IUCLID Dataset searched on 6/3/2010.

ACUTE INHALATION TOXICITY FOR THE COMPONENTS:

Component: 2-Butoxyethanol
Species: Rat
LD50: 700 mg/l (7 hrs)
Remarks: This data was sourced from the supplier MSDS.

Component: Organic Sulfonic Acid Salt
Species: Rat
LD50: 20 mg/l (96 hrs)
Remarks: This data was sourced from an IUCLID Dataset searched on 6/2/2010.

CHRONIC TOXICITY DATA FOR THE COMPONENT: 2-Butoxyethanol

The principal health effects following acute exposure to 2-butoxyethanol are irritation of the eyes and respiratory tract. 2-butoxyethanol is readily absorbed through the skin. In laboratory animals exposed to 2-butoxyethanol via inhalation, blood (hemolysis) and secondary effects on the kidney and liver have been observed. When 2-butoxyethaol is ingested it is metabolized to butoxyacetic acid (BAA), which can cause hemolysis. BAA is rapidly excreted in urine in animals and humans with a urinary excretion half-life of approximately 3-6 hours in humans. Human red blood cells have been shown to be significantly less sensitive to hemolysis than those of rodents and rabbits. These effects are transient and when exposure is discontinued, these effects subside. 2-butoxyethanol does not cause adverse reproductive or birth effects in animals, unless exposures occur at levels high enough to induce significant maternal toxicity.

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12. ECOLOGICAL INFORMATION

ECOTOXICOLOGICAL EFFECTS :

The following results are for the product, unless otherwise indicated.

Acute Fish Results :

Species	Exposure	Test Type	Value	Test Descriptor
Turbot	96 hrs	LC50	50 mg/l	Product
Fathead Minnow	96 hrs	LC50	201 mg/l	Product
Inland Silverside	96 hrs	LC50	14.57 mg/l	Product
Common Mummichog	96 hrs	LC50	81 mg/l	Product

ACUTE INVERTEBRATE RESULTS :

Species	Exposure	Test Type	Value	Test Descriptor
Acartia tonsa	48 hrs	LC50	23 mg/l	Product
Mysid Shrimp (Mysidopsis bahia)	48 hrs	LC50	24.14 mg/l	Product
Artemia	48 hrs	LC50	40 mg/l	Product

AQUATIC PLANT RESULTS :

Species	Exposure	Test Type	Value	Test Descriptor
Marine Algae (Skeletonema costatum)	72 hrs	EC50	9.4 mg/l	Product

MOBILITY :
The environmental fate was estimated using a level III fugacity model embedded in the EPI (estimation program interface) Suite TM, provided by the US EPA. The model assumes a steady state condition between the total input and output. The level III model does not require equilibrium between the defined media. The information provided is intended to give the user a general estimate of the environmental fate of this product under the defined conditions of the models.
If released into the environment this material is expected to distribute to the air, water and soil/sediment in the approximate respective percentages;

Air	Water	Soil/Sediment
<5%	10 - 30%	70 - 90%

The portion in water is expected to be soluble or dispersible.

BIOACCUMULATION POTENTIAL
Based on a review of the individual components, utilizing U.S. EPA models, this material is not expected to bioaccumulate.

ENVIRONMENTAL HAZARD AND EXPOSURE CHARACTERIZATION
Based on our hazard characterization, the potential environmental hazard is: Moderate
Based on our recommended product application and the product's characteristics, the potential environmental exposure is: Low

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If released into the environment, see CERCLA/SUPERFUND in Section 15.

13. DISPOSAL CONSIDERATIONS

If this product becomes a waste, it is not a hazardous waste as defined by the Resource Conservation and Recovery Act (RCRA) 40 CFR 261, since it does not have the characteristics of Subpart C, nor is it listed under Subpart D.

As a non-hazardous waste, it is not subject to federal regulation. Consult state or local regulation for any additional handling, treatment or disposal requirements. For disposal, contact a properly licensed waste treatment, storage, disposal or recycling facility.

14. TRANSPORT INFORMATION

The information in this section is for reference only and should not take the place of a shipping paper (bill of lading) specific to an order. Please note that the proper Shipping Name / Hazard Class may vary by packaging, properties, and mode of transportation. Typical Proper Shipping Names for this product are as follows.

LAND TRANSPORT :

Proper Shipping Name : PRODUCT IS NOT REGULATED DURING TRANSPORTATION

AIR TRANSPORT (ICAO/IATA) :

Proper Shipping Name : PRODUCT IS NOT REGULATED DURING TRANSPORTATION

MARINE TRANSPORT (IMDG/IMO) :

Proper Shipping Name : PRODUCT IS NOT REGULATED DURING TRANSPORTATION

15. REGULATORY INFORMATION

This section contains additional information that may have relevance to regulatory compliance. The information in this section is for reference only. It is not exhaustive, and should not be relied upon to take the place of an individualized compliance or hazard assessment. Nalco accepts no liability for the use of this information.

NATIONAL REGULATIONS, USA :

OSHA HAZARD COMMUNICATION RULE, 29 CFR 1910.1200 :
Based on our hazard evaluation, none of the substances in this product are hazardous.

CERCLA/SUPERFUND, 40 CFR 302 :
Notification of spills of this product is not required.

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SARA/SUPERFUND AMENDMENTS AND REAUTHORIZATION ACT OF 1986 (TITLE III) - SECTIONS 302, 311, 312, AND 313 :

SECTION 302 - EXTREMELY HAZARDOUS SUBSTANCES (40 CFR 355) :
This product does not contain substances listed in Appendix A and B as an Extremely Hazardous Substance.

SECTIONS 311 AND 312 - MATERIAL SAFETY DATA SHEET REQUIREMENTS (40 CFR 370) :
Our hazard evaluation has found this product to be hazardous. The product should be reported under the following indicated EPA hazard categories:

X	Immediate (Acute) Health Hazard
X	Delayed (Chronic) Health Hazard
X	Fire Hazard
	Sudden Release of Pressure Hazard
	Reactive Hazard

Under SARA 311 and 312, the EPA has established threshold quantities for the reporting of hazardous chemicals. The current thresholds are: 500 pounds or the threshold planning quantity (TPQ), whichever is lower, for extremely hazardous substances and 10,000 pounds for all other hazardous chemicals.

SECTION 313 - LIST OF TOXIC CHEMICALS (40 CFR 372) :
This product contains the following substance(s), (with CAS # and % range) which appear(s) on the List of Toxic Chemicals

Hazardous Substance(s)	CAS NO	% (w/w)
Glycol Ethers		30 - 60

TOXIC SUBSTANCES CONTROL ACT (TSCA) :
The substances in this preparation are included on or exempted from the TSCA 8(b) Inventory (40 CFR 710)

FEDERAL WATER POLLUTION CONTROL ACT, CLEAN WATER ACT, 40 CFR 401.15 / formerly Sec. 307, 40 CFR 116.4 / formerly Sec. 311 :
Substances listed under this regulation are not intentionally added or expected to be present in this product. Listed components may be present at trace levels.

CLEAN AIR ACT, Sec. 112 (Hazardous Air Pollutants, as amended by 40 CFR 63), Sec. 602 (40 CFR 82, Class I and II Ozone Depleting Substances) :
Substances listed under this regulation are not intentionally added or expected to be present in this product. Listed components may be present at trace levels.

CALIFORNIA PROPOSITION 65 :
Substances listed under California Proposition 65 are not intentionally added or expected to be present in this product.

MICHIGAN CRITICAL MATERIALS :
Substances listed under this regulation are not intentionally added or expected to be present in this product. Listed components may be present at trace levels.

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STATE RIGHT TO KNOW LAWS :
The following substances are disclosed for compliance with State Right to Know Laws:

2-Butoxyethanol	111-76-2
Propylene Glycol	57-55-6

INTERNATIONAL CHEMICAL CONTROL LAWS :

CANADIAN ENVIRONMENTAL PROTECTION ACT (CEPA) :
The substances in this preparation are listed on the Domestic Substances List (DSL), are exempt, or have been reported in accordance with the New Substances Notification Regulations.

AUSTRALIA
All substances in this product comply with the National Industrial Chemicals Notification & Assessment Scheme (NICNAS).

CHINA
All substances in this product comply with the Provisions on the Environmental Administration of New Chemical Substances and are listed on or exempt from the Inventory of Existing Chemical Substances China (IECSC).

EUROPE
The substance(s) in this preparation are included in or exempted from the EINECS or ELINCS inventories

JAPAN
All substances in this product comply with the Law Regulating the Manufacture and Importation Of Chemical Substances and are listed on the Existing and New Chemical Substances list (ENCS).

KOREA
All substances in this product comply with the Toxic Chemical Control Law (TCCL) and are listed on the Existing Chemicals List (ECL)

PHILIPPINES
All substances in this product comply with the Republic Act 6969 (RA 6969) and are listed on the Philippines Inventory of Chemicals & Chemical Substances (PICCS).

16. OTHER INFORMATION

Due to our commitment to Product Stewardship, we have evaluated the human and environmental hazards and exposures of this product. Based on our recommended use of this product, we have characterized the product's general risk. This information should provide assistance for your own risk management practices. We have evaluated our product's risk as follows:

* The human risk is: Low

* The environmental risk is: Low

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Any use inconsistent with our recommendations may affect the risk characterization. Our sales representative will assist you to determine if your product application is consistent with our recommendations. Together we can implement an appropriate risk management process.

This product material safety data sheet provides health and safety information. The product is to be used in applications consistent with our product literature. Individuals handling this product should be informed of the recommended safety precautions and should have access to this information. For any other uses, exposures should be evaluated so that appropriate handling practices and training programs can be established to insure safe workplace operations. Please consult your local sales representative for any further information.

REFERENCES

Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices, American Conference of Governmental Industrial Hygienists, OH., (Ariel Insight™ CD-ROM Version), Ariel Research Corp., Bethesda, MD.

Hazardous Substances Data Bank, National Library of Medicine, Bethesda, Maryland (TOMES CPS™ CD-ROM Version), Micromedex, Inc., Englewood, CO.

IARC Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man, Geneva: World Health Organization, International Agency for Research on Cancer.

Integrated Risk Information System, U.S. Environmental Protection Agency, Washington, D.C. (TOMES CPS™ CD-ROM Version),
Micromedex, Inc., Englewood, CO.

Annual Report on Carcinogens, National Toxicology Program, U.S. Department of Health and Human Services, Public Health Service.

Title 29 Code of Federal Regulations, Part 1910, Subpart Z, Toxic and Hazardous Substances, Occupational Safety and Health Administration (OSHA), (Ariel Insight™ CD-ROM Version), Ariel Research Corp., Bethesda, MD.

Registry of Toxic Effects of Chemical Substances, National Institute for Occupational Safety and Health, Cincinnati, OH,
(TOMES CPS™ CD-ROM Version), Micromedex, Inc., Englewood, CO.

Ariel Insight™ (An integrated guide to industrial chemicals covered under major regulatory and advisory programs), North American Module, Western European Module, Chemical Inventories Module and the Generics Module (Ariel Insight™ CD-ROM Version), Ariel Research Corp., Bethesda, MD.

The Teratogen Information System, University of Washington, Seattle, WA (TOMES CPS™ CD-ROM Version), Micromedex, Inc., Englewood, CO.

Prepared By : Product Safety Department
Date issued : 03/01/2012

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Version Number : 4.3

B.2.

B.2.a.

B.2.a.(1).

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B.13.

B.14.

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B.2.a.

B.2.a.(1).

B.3.

B.4.

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7)
Air Monitoring Log Example

C.1. Below is typical data from Air Monitoring Log

USCG AST Air Monitoring Log for Bristolville Crude Oil Release – Controlled burn

14 May 2013

0820 calibrated two MultiRAEs and four DataRAMs (D432, D433, D435, D436)

0854 started D436 southeast of first burn area
Background = 4.0 ug/m3
N 41 degrees, 25.163 minutes
W 80 degrees, 49.552 minutes
0900 started D435 approximately 100 yards north of burn area
BG=6.5 ug/m3
N 41 degrees, 25.262 minutes
W 80 degrees, 49.577 minutes
0906 started D432 west of burn area
BG=5.5 ug/m3
N 41 degrees, 25.226 minutes
W 80 degrees, 49.677 minutes
0909 started D433 southwest of burn area
BG=7.4 ug/m3
N 41 degrees, 25.176 minutes
W 80 degrees, 49.628 minutes
0930 safety briefing

0935 (approx) start of burn

wind from south to north. Smoke remained low to ground.
0940 readings at D435 over 2000 ug/m3
D435 was moved approximately 200 yards farther north to
N 41 degrees, 25.362 minutes
W 80 degrees, 49.600 minutes

0952 wind shifted. Now blowing southeast to northwest.
Readings declined at D435

First burn finished

1045 moved D435 into position north of second burn area.
N 41 degrees, 25.389 minutes

W 80 degrees, 49.684 minutes

moved D436 into position west of second burn area.
N 41 degrees, 25.262 minutes
W 80 degrees, 49.780 minutes

1310 background at D436=4.4 ug/m3
1317 background at D435=8.8 ug/m3

1344 start of second burn. wind blowing southeast to northwest. Smoke rising vertically more than first burn.

1430 burn completed

1440 kept DD435 running and moved to location of D436, west of burn with residual smoke detected.

1450 stopped all four DataRAMs

C.2.

C.2.a.

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7)
Data RAM Raw Data Example

D.1. Raw Data

Below is raw data from the Data Ram and then a chart that calculates the TWA (Time Weighted Average).

D.1.a. Settings

"Model Number", "DataRAM 4 ", 106

"Serial no. ", "D435 "

"Device no. ", 1

"Tag Number ", 1

"Start Time ", 09:00:39

"Start Date ", 14-May-2013

"Log Period ", 00:01:00

"Number ", 348

"CalFactor ", 1.000000

"Unit ", 0

"Unit Name ", "(MASS)ug/m3"

"SIZE_CORRECT", "DISABLED"

"TEMPUNITS ", F

"Max MASS ", 6212.361000

"Max MASS @ ", 43 ,09:43:39 ,14-May-2013

"Avg MASS ", 124.506000

"Max Diam ", 3.139077

"Max Diam @ ", 82 ,10:22:39 ,14-May-2013

"Avg Diam ", 0.918179

"ALARM ", "DISABLED"

"ALARM_LEVEL ", 0.0

"AUTO_ZERO ", "DISABLED"

"AZ INTERVAL ", 1

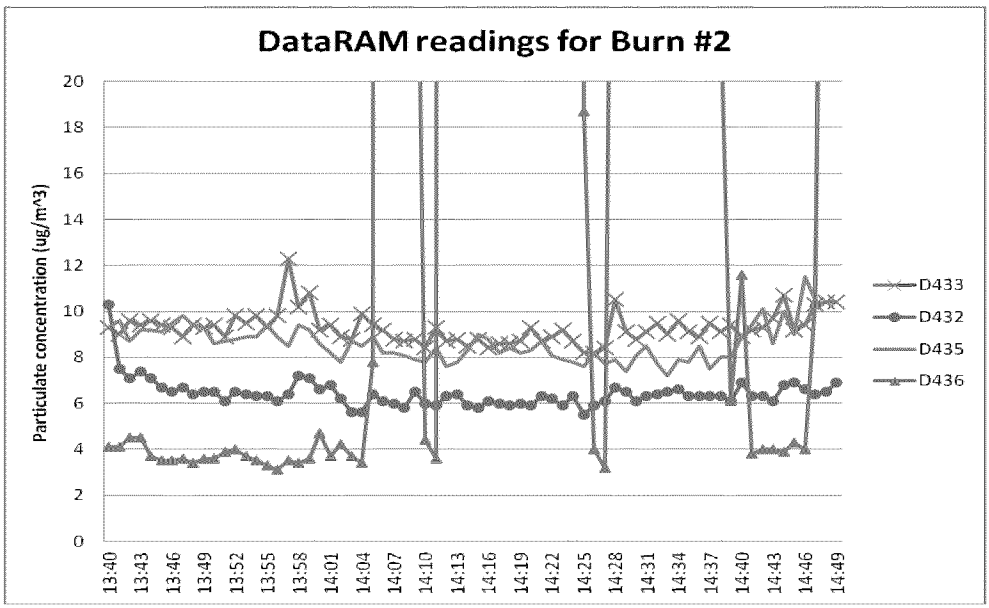
"Errors ", 0000

record,"(MASS)ug/m3", Temp, RHumidity, Diameter

D.1.b. Data Readings

1,	6.3,	61.1,	50,	0.4196	,09:01:39	,14-May-2013
2,	7.0,	60.9,	49,	0.5674	,09:02:39	,14-May-2013
3,	8.0,	60.8,	47,	0.7665	,09:03:39	,14-May-2013
4,	6.5,	60.7,	46,	0.5775	,09:04:39	,14-May-2013
5,	7.5,	60.5,	45,	0.6722	,09:05:39	,14-May-2013
6,	7.0,	60.3,	44,	0.6111	,09:06:39	,14-May-2013
7,	6.9,	60.2,	44,	0.5167	,09:07:39	,14-May-2013
8,	6.9,	60.0,	43,	0.5591	,09:08:39	,14-May-2013
9,	6.9,	59.8,	42,	0.5360	,09:09:39	,14-May-2013
10,	7.1,	59.7,	42,	0.5648	,09:10:39	,14-May-2013
11,	6.9,	59.5,	42,	0.6182	,09:11:39	,14-May-2013

D.2. Data Averaged over 3 seconds



D.3. TSI DustTrack DRX 8533 data

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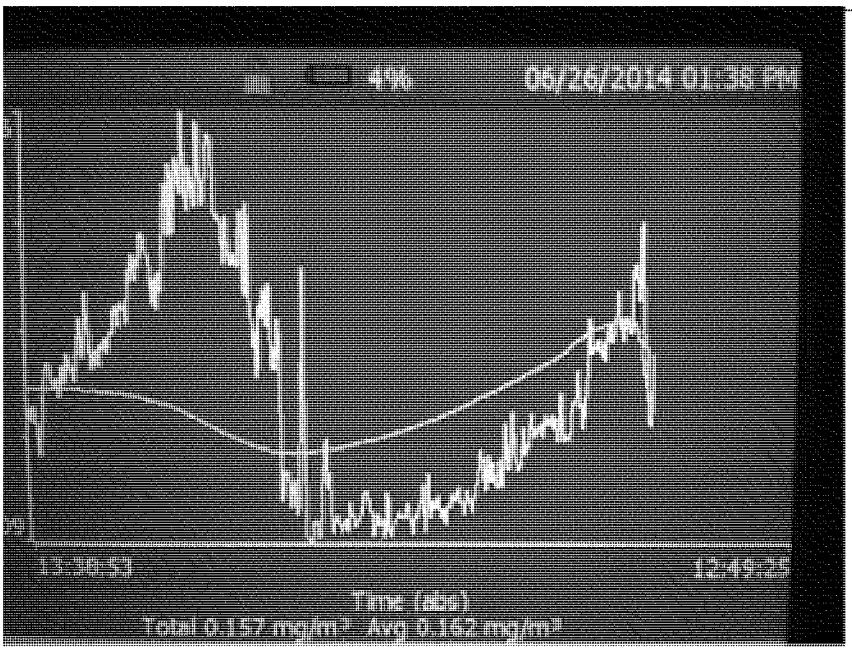

D.4.

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D.16. _____

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D.17. _____

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D.18. _____

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D.19. _____

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D.20. _____

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7)
ICS Compatible Site Safety and Health Plan Template

E.1.	

FORM NAME	FORM #	USE	REQUIRED	OPTIONAL	ATTACHED?
Emergency Safety and Response Plan	A	Emergency response phase (uncontrolled)	X		
Site Safety Plan	B	Post-emergency phase (stabilized, cleanup)	X		
Site Map	C	Post-emergency phase map of site and hazards	X		
Emergency Response Plan	D	Part of Form B, to address emergencies	X		
Air Monitoring Log	E	To log air monitoring data	X*		
Personal Protective Equipment	F	To document PPE equipment and procedures	X*		
Decontamination	G	To document decon equipment and procedures	X*		
Site Safety Enforcement Log	H	To use in enforcing safety on site		X	
Worker Acknowledgement Form	I	To document workers receiving briefings		X	
Form A Compliance Checklist	J	To assist in ensuring HAZWOPER compliance		X	
Form B Compliance Checklist	K	To assist in ensuring HAZWOPER compliance		X	
Drum Compliance Checklist	L	To assist in ensuring HAZWOPER compliance		X	
Other:					

EMERGENCY SAFETY and RESPONSE PLAN	1. Incident Name	2. Date/Time Prepared	3. Operational Period	4. Attachments: **Attach MSDS for each Chemical**
5. Organization IC:	Safety: Group Supv:	Entry Team:	Backup Team:	Decon Team:

6. Physical Hazards and Protection: Confined Space ☐ Noise ☐ Heat Stress ☐ Cold Stress ☐ Electrical ☐ Animal/Plant/Insect ☐ Ergonomic ☐ Ionizing Rad ☐ Slips/Trips/Falls ☐ Struck by ☐ Water ☐ Violence ☐ Excavation ☐ Biomedical waste and/or needles ☐ Fatigue ☐ Other (specify)

Major Tasks	Entry Permit	Ventilate	Hearing Protection	Shoes (type)	Hard Hats	Clothing (cold wx)	Life Jacket	Work/ Rest (hrs)	Fluids (amt/time)	Signs and Barricade	Fall Protect	Post Guards	Flash Protect	Work Gloves	Other

7. Chemicals	Hazards		Target Organs	Exposure Routes	PPE	Type of PPE
	Explosive ☐ Flammable ☐ Reactive ☐ Biomedical ☐ Toxic ☐	Radioactive ☐ Carcinogen ☐ Oxidizer ☐ Corrosive ☐ Specify Other:	Eyes ☐ Nose ☐ Skin ☐ Ears ☐ Central Nervous System ☐ Respiratory ☐ Throat ☐ Lungs ☐ Heart ☐ Liver ☐ Kidney ☐ Blood ☐ Lungs ☐ Circulatory ☐ Gastrointestinal ☐ Bone ☐ Other:	Inhalation ☐ Absorption ☐ Ingestion ☐ Injection ☐ Membrane ☐ ☐	Face Shield ☐ Eyes ☐ Gloves ☐ Inner Suit ☐ Splash Suit ☐ Level A Suit ☐ SCBA ☐ APR ☐ SAR ☐ Cartridges ☐ Fire Resistance ☐	

8. Instruments	Action Levels	Chemical Name:	LEL/UEL %	Odor Thresh Ppm	Ceiling/ IDLH	STEL/TLV	Flash Point/ Ignition Pt (F or C)	Vapor Pressure (mm)	Vapor Density	Specific Gravity	Boiling Point F or C
O2 ☐											
CGI ☐											
Radiation ☐											
Total HCs ☐											
Colorimetric ☐											
Thermal ☐											
Other ☐											

Form SSP-A:
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10. Site Map. Include: Work Zones, Locations of Hazards, Security Perimeter, Places of Refuge, Decontamination Line, Evacuation Routes, Assembly Point, Direction of North				
11. Decontamination: Instrument Drop Off ☐ Outer Boots/Glove Removal ☐ Suit/Gloves/Boot Disposal ☐	Suit Wash ☐ Decon Agent: Water ☐ Other ☐ Specify:	Bottle Exchange ☐ Outer Suit Removal ☐ Inner Suit Removal ☐ SCBA/Mask Removal ☐	SCBA/Mask Rinse ☐ Inner Glove Removal ☐ Work Clothes Removal ☐ Body Shower ☐	Intervening Steps ☐Specify:
12. Potential Emergencies Fire ☐ Explosion ☐ Other ☐	Evacuation Alarms: Horn ☐ # Blasts ☐ Bells ☐ #Rings ☐ Radio Code ☐ Other:	Emergency Prevention and Evacuation Procedures: Safe Distance		
13. Communications: Radio? ☐ Phone? ☐	Command #:	Tactical #:	Entry #:	
14. Site Security Personnel Assigned ____	Procedures:		Equipment	
15. Emergency Medical Personnel Assigned ____	Procedures:		Equipment	
16. Prepared By:	17. Date/Time Briefed: ____			**Form SSP-A:** Page of

CG ICS SITE SAFETY PLAN (SSP) HAZARD ID/EVAL/CONTROL	1. Incident Name	2. Date/Time Prepared	3. Operational Period	4. Safety Officer (include method of contact
5. Supervisor/Leader	6. Location and Size of Site	7. Site Accessibility Land☐ Water☐ Air ☐ Comments:	8. For Emergencies Contact:	9. Attachments: **Attach MSDS for each Chemical**
10. Job Task/Activity	Hazards* ⇨	Potential Injury and Health Effects	Exposure Routes	Controls: Engineering, Administrative, PPE
			Inhalation ☐ Absorption ☐ Ingestion ☐ Injection ☐ Membrane ☐ ☐	
			Inhalation ☐ Absorption ☐ Ingestion ☐ Injection ☐ Membrane ☐ ☐	
			Inhalation ☐ Absorption ☐ Ingestion ☐ Injection ☐ Membrane ☐ ☐	
			Inhalation ☐ Absorption ☐ Ingestion ☐ Injection ☐ Membrane ☐ ☐	
			Inhalation ☐ Absorption ☐ Ingestion ☐ Injection ☐ Membrane ☐ ☐	
11. Prepared By:	12. Date/Time Briefed:	***HAZARD LIST**: Physical/Safety, Toxic, Explosion/Fire, Oxygen Deficiency, Ionizing Radiation, Biological, Biomedical, Electrical, Heat Stress, Cold Stress, Ergonomic, Noise, Cancer, Dermatitis, Drowning, Fatigue, Vehicle, Diving		**Form SSP-B:** Page of

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CG ICS SSP: SITE MAP	1. Incident Name	2. Date/Time Prepared	3. Operational Period	4. Safety Officer (include method of contact)
5. Supervisor/Leader	6. Location and Size of Site	7. Site Accessibility Land☐ Water☐ Air ☐ Comments:	8. For Emergencies Contact:	9. Include: - Work Zones - Locations of Hazards - Security Perimeter - Places of Refuge - Decontamination Line - Evacuation Routes
10. Sketch of Site:				
11. Prepared By:	12. Date/Time Briefed:	**HAZARD LIST**: Physical/Safety, Toxic, Explosion/Fire, Oxygen Deficiency, Ionizing Radiation, Biological, Biomedical, Electrical, Heat Stress, Cold Stress, Ergonomic, Noise, Cancer, Dermatitis, Drowning, Fatigue, Vehicle, Diving		**Form SSP-C:** Page of

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CG ICS SSP: EMERGENCY RESPONSE PLAN	1. Incident Name	2. Date/Time Prepared	3. Operational Period	4. Safety Officer (include method of contact)
5. Supervisor/Leader	6. Location and Size of Site	7. For Emergencies Contact:		8. Attachments: **INCLUDE ICS FORM 206 and EMT Medical Response Procedures**
9. Emergency Alarm (sound and location)	10. Backup Alarm (sound and location)	11. Emergency Hand Signals	12. Emergency Personal Protective Equipment Required:	

13. Emergency Notification Procedures	14. Places of Refuge (also see site map form 208B)	15. Emergency Decon and Evacuation Steps	16. Site Security Measures

17. Prepared By:	18. Date/Time Briefed:	**HAZARD LIST**: Physical/Safety, Toxic, Explosion/Fire, Oxygen Deficiency, Ionizing Radiation, Biological, Biomedical, Electrical, Heat Stress, Cold Stress, Ergonomic, Noise, Cancer, Dermatitis, Drowning, Fatigue, Vehicle, Diving	**Form SSP-D:** Page of

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CG ICS SSP: AIR MONITORING LOG	1. Incident Name	2. Date/Time Prepared	3. Operational Period	4. Safety Officer (include method of contact)	
5. Site Location	6. Hazards of Concern	7. Action Levels (include references):		8. Weather: Temperature: Precipitation: Wind: Relative Humidity: Cloud Cover:	
9. Instrument, ID Number Calibrated? Indicate below.	Monitoring Person Name(s)	Results (units)	Location	Time	Interferences and Comments
10. Safety Officer Review:		Potential Health Effects: Bruise/Lacerations, Organ Damage, Central Nervous System Effects, Cancer, Reproductive Damage, Low Back Pain, Temporary Hearing Loss, Dermatitis, Respiratory Effects, Bone Breaks, Eye Burning			**Form SSP-E:** Page of

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CG ICS SSP: PERSONAL PROTECTIVE EQUIPMENT	1. Incident Name	2. Date/Time Prepared	3. Operational Period	4. Safety Officer (include method of contact)
5. Supervisor/Leader	6. Location and Size of Site	7. Hazards Addressed:		8. For Emergencies Contact:

9. Equipment:				10. References Consulted:

11. Inspection Procedures:	12. Donning Procedures:	13. Doffing Procedures:	14. Limitations and Precautions (include maximum stay time in PPE):

15. Prepared By:	16. Date/Time Briefed:	Potential Health Effects: Bruise/Lacerations, Organ Damage, Central Nervous System Effects, Cancer, Reproductive Damage, Low Back Pain, Temporary Hearing Loss, Dermatitis, Respiratory Effects, Bone Breaks, Eye Burning	**Form SSP-F:** Page of

CG ICS SSP: DECONTAMINATION	1. Incident Name	2. Date/Time Prepared	3. Operational Period	4. Safety Officer (include method of contact)
5. Supervisor/Leader	6. Location and Size of Site	7. For Emergencies Contact:		8. Hazard(s) Addressed:

9. Equipment:				10. References Consulted:

11. Contamination Avoidance Practices:	12. Decon Diagram	13. Decon Steps

14. Prepared By:	15. Date/Time Briefed:	Potential Health Effects: Bruise/Lacerations, Organ Damage, Central Nervous System Effects, Cancer, Reproductive Damage, Low Back Pain, Temporary Hearing Loss, Dermatitis, Respiratory Effects, Bone Breaks, Eye Burning	**Form SSP-G:** Page of

CG ICS SSP: ENFORCEMENT LOG	1. Incident Name	2. Date/Time Prepared	3. Operational Period	4. Safety Officer (include method of contact)	
5. Supervisor/Leader	6. For Emergencies Contact:			7. Attachments:	
8. Job Task/Activity	Hazards	Deficiency	Action Taken	Safety Plan Amended?	Signature of Supervisor/Leader
9. Prepared By:	10. Date/Time Briefed:	**HAZARD LIST**: Physical/Safety, Toxic, Explosion/Fire, Oxygen Deficiency, Ionizing Radiation, Biological, Biomedical, Electrical, Heat Stress, Cold Stress, Ergonomic, Noise, Cancer, Dermatitis, Drowning, Fatigue, Vehicle, Diving			**Form SSP-H:** Page of

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CG ICS SSP WORKER ACKNOWLEDGEMENT FORM	1. Incident Name	2. Site Location:	3. Attachments:

4. Type of Briefing	5. Presented By:	6. Date	7. Time
Safety Plan/Emergency Response Plan ☐ Start Shift ☐ Pre-Entry ☐ Exit ☐ End of Shift ☐ Specify Other:			
8. Worker Name (Print)	Signature*	Date	Time

* *By signing this document, I am stating that I have read and fully understand the plan and/or information provided to me.*	**SSP-I: Worker Acknowledgement** **Page of**

5. Location of Site				
CG ICS Emergency Response Plan 1910.120 COMPLIANCE CHECKLIST	1. Incident Name	2. Date/Time Prepared	3. Operational Period	4. Site Supervisor/Leader

Cite: 1910.120	Requirement(sections that duplicate or explain are omitted)	ICS Form	[4]	Comments
(**q**)(1)	Is the plan in writing?	SSP-A	☐	
(1)	Is the plan available for inspection by employees?	N/A	☐	Performance based
(**q**)(2)(i)	Does the plan address pre-emergency planning and coordination?	SSP-A	☐	
(ii)	Does it address personnel roles?	SSP-A	☐	
(ii)	Does it address lines of authority?	SSP-A	☐	
(ii)	Does it address communications?	SSP-A	☐	
(iii)	Does it address emergency recognition?	SSP-A	☐	
(iii)	Does it address emergency prevention?	SSP-A	☐	
(iv)	Does it identify safe distances?	SSP-A	☐	
(iv)	Does it address places of refuge?	SSP-A	☐	
(v)	Does it address site security and control?	SSP-A	☐	
(vi)	Does it identify evacuation routes?	SSP-A	☐	
(vi)	Does it identify evacuation procedures?	SSP-A	☐	
(vii)	Does it address decontamination?	SSP-A	☐	
(viii)	Does it address medical treatment and first aid?	SSP-A	☐	
(ix)	Does it address emergency alerting procedures?	SSP-A	☐	
(ix)	Does it address emergency response procedures	SSP-A	☐	
(x)	Was the response critiqued?	N/A	☐	Performance based
(xi)	Does it identify Personal Protection Equipment?	SSP-A	☐	
(xi)	Does it identify emergency equipment?	SSP-A	☐	
(**q**)(3)(ii)	All the hazardous substances identified to the extent possible?	N/A	☐	Performance based
(ii)	All the hazardous conditions identified to the extent possible?	N/A	☐	Performance based
(ii)	Was site analysis addressed?	N/A	☐	Performance based
(ii)	Were engineering controls addressed?	N/A	☐	Performance based
(ii)	Were exposure limits addressed?	N/A	☐	Performance based
(ii)	Were hazardous substance handling procedures addressed?	N/A	☐	Performance based
(iii)	Is the PPE appropriate for the hazards identified?	N/A	☐	Performance based
(iv)	Is respiratory protection worn when inhalation hazards present?	N/A	☐	Performance based
(v)	Is the buddy system used in the hazard zone?	N/A	☐	Performance based
(vi)	Are backup personnel on standby?	N/A	☐	Performance based
(vi)	Are advanced first aid support personnel standing by?	N/A	☐	Performance based
(vii)	Has the ICS designated safety official been identified?	SSP-A	☐	
(vii)	Has the Safety Official evaluated the hazards?	N/A	☐	Performance based
(viii)	Can the Safety Official communicate with IC immediately?	N/A	☐	Performance based
(ix)	Are appropriate decontamination procedures implemented?	N/A	☐	Performance based

Form SSP-J

ED_001324_00008411-00123

CG ICS SSP: 1910.120 COMPLIANCE CHECKLIST	1. Incident Name	2. Date/Time Prepared	3. Operational Period	4. Site Supervisor/Leader	5. Location of Site

Cite: 1910.120	Requirement(sections that duplicate or explain are omitted)	ICS Form	[4]	Comments
(**b**)(1)(ii)(A)	Organizational structure?	203	☐	
(B)	Comprehensive workplan?	IAP	☐	Incident Action Plan
(C)	Site Safety Plan?	SSP-B	☐	
(D)	Safety and health training program?	N/A	☐	Responsibility of each employer
(E)	Medical surveillance program?	N/A	☐	Responsibility of each employer
(F)	Employer SOPs?	N/A	☐	Responsibility of each employer
(G)	Written program related to site activities?	N/A	☐	
(**b**)(1)(iii)	Site excavation meets shored or slope requirements in 1926?	N/A	☐	
(**b**)(2)(i)(D)	Lines of communication?	201 203 205	☐	
(**b**)3(iv)	Training addressed?	N/A	☐	Responsibility of each employer
(v)-(vi)	Information and medical monitoring addressed?	N/A	☐	Responsibility of each employer
(**b**)4(i)	Site Safety Plan kept on site?	N/A	☐	
(ii)(A)	Safety and health hazard analysis conducted?	N/A	☐	
(B)	Properly trained employees assigned to right jobs?	N/A	☐	
(C)	Personnel Protective Equipment issues addressed?	SSP-F	☐	
(E)	Frequency and types of air monitoring addressed?	SSP-E	☐	
(F)	Site control measures in place?	SSP-B	☐	
(G)	Decontamination procedures in place?	SSP-G	☐	
(H)	Emergency Response Plan in place?	SSP-D	☐	
(I)	Confined space entry procedures?	SSP-B	☐	
(J)	Spill containment program	SSP-B	☐	
(iii)	Pre-entry briefings conducted?	SSP-I	☐	
(iv)	Site Safety Plan effectiveness evaluated?	SSP-H	☐	
(**c**)(1)	Site characterization done?	N/A	☐	
(**c**)(2)	Preliminary evaluation done by qualified person?	N/A	☐	
(**c**)(3)	Hazard identification performed?	SSP-B	☐	
(**c**)(4)(i)	Location and size of site identified?	SSP-B	☐	
(ii)	Response activities, job tasks identified?	SSP-B	☐	
(iii)	Duration of tasks identified?	SSP-B	☐	Operational period
(iv)	Site topography and accessibility addressed?	SSP-C	☐	
(v)	Health and safety hazards addressed?	SSP-B	☐	
(vi)	Dispersion pathways addressed?	SSP-B	☐	
(vii)	Status and capabilities of medical emergency response teams?	206	☐	
(**c**)(5)(i)(iv)	Chemical protective clothing addressed and properly selected?	SSP-F	☐	
(ii)	Respiratory protection addressed?	SSP-B and F	☐	
(iii)	Level B used for unknowns?	N/A	☐	
(**c**)(6)(i)	Monitoring for ionization conducted?	SSP-E	☐	
(ii)	Monitoring conducted for IDLH conditions?	SSP-E	☐	
(iii)	Personnel looking out for dangers of IDLH environments?	N/A	☐	
(iv)	Ongoing air monitoring program in place?	SSP-E	☐	

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CG ICS SSP: 1910.120 COMPLIANCE CHECKLIST	1. Incident Name	2. Date/Time Prepared	3. Operational Period		
Cite: 1910.120	Requirement		ICS Form	[4]	Comments
(**c**)(7)	Employees informed of potential hazard occurrence?		SSP-B	☐	
(**c**)(8)	Properties of each chemical made aware to employees?		SSP-B	☐	
(**d**)(1)	Appropriate site control procedures in place?		IAP, SSP-B	☐	
(**d**)(2)	Site control program developed during planning stages?		IAP, SSP-B	☐	
(**d**)(3)	Site map, work zones, alarms, communications addressed?		IAP, SSP-B	☐	
(**g**)(1)(i)	Engineering, admin controls considered?		SSP-B	☐	
(iii)	Personnel not rotated to reduce exposures?		N/A	☐	
(**g**)(5)(i)	PPE selection criteria part of employer's program?		N/A	☐	Responsibility of employer
(ii)	PPE use and limitations identified?		SSP-F	☐	
(iii)	Work mission duration identified?		SSP-F	☐	
(iv)	PPE properly maintained and stored?		N/A	☐	Responsibility of employer
(vi)	Are employees properly trained and fitted with PPE?		N/A	☐	Responsibility of employer
(vii)	Are donning and doffing procedures identified?		SSP-F	☐	
(viii)	Are inspection procedures properly identified?		SSP-F	☐	
(ix)	Is a PPE evaluation program in place?		SSP-F	☐	
(**h**) (3)	Periodic monitoring conducted?		SSP-E	☐	
(**k**)(2)(i)	Have decontamination procedures been established?		SSP-G	☐	
(ii)	Are procedures in place for contamination avoidance?		SSP-G	☐	
(iii)	Is personal clothing properly deconned prior to leaving the site?		SSP-G	☐	
(iv)	Are decontamination deficiencies identified and corrected?		SSP-H	☐	
(**k**)(3)	Are decontamination lines in the proper location?		SSP-C	☐	
(**k**)(4)	Are solutions/equipment used in decon properly disposed of?		N/A	☐	
(**k**)(6)	Is protective clothing and equipment properly secured?		N/A	☐	
(**k**)(7)	If cleaning facilities are used, are they aware of the hazards?		N/A	☐	
(**k**)(8)	Have showers and change rooms provided, if necessary?		N/A	☐	
(**l**)(1)(iii)	Are provisions for reporting emergencies identified?		SSP-D	☐	
(iv)	Are safe distances and places of refuge identified?		SSP-B and C	☐	
(v)	Site security and control addressed in emergencies?		SSP-D	☐	
(vi)	Evacuation routes and procedures identified?		SSP-D	☐	
(vii)	Emergency decontamination procedures developed?		SSP-D	☐	
(ix)	Emergency alerting and response procedures identified?		SSP-D	☐	
(x)	Response teams critiqued and followup performed?		SSP-H	☐	
(xi)	Emergency PPE and equipment available?		SSP-D	☐	
(**l**)(3)(i)	Emergency notification procedures identified?		SSP-D	☐	
(ii)	Emergency response plan separate from Site Safety Plan?		SSP-D	☐	
(iii)	Emergency response plan compatible with other plans?		SSP-D	☐	
(iv)	Emergency response plan rehearsed regularly?		SSP-D	☐	
(v)	Emergency response plan maintained and kept current?		SSP-H	☐	
1910.165(**b**)(2)	Can alarms be seen/heard above ambient light and noise levels?		N/A	☐	
(**b**)(3)	Are alarms distinct and recognizable?		N/A	☐	
					Form SSP-K: Page 2

CG ICS SSP: 1910.120 COMPLIANCE CHECKLIST	1. Incident Name	2. Date/Time Prepared	3. Operational Period		
Cite: 1910.165	Requirement		ICS Form	[4]	Comments
(**b**)(4)	Are employees aware of the alarms and are they accessible?		SSP-D	☐	
(**b**)(5)	Are emergency phone numbers, radio frequencies clearly posted?		206	☐	
(**b**)(6)	Signaling devices in place where there are 10 or more workers?		IAP	☐	
(**c**)(1)	Are alarms like steam whistles, air horns being used?		IAP	☐	
(**d**)(3)	Are backup alarms available?		IAP	☐	
1910.120(m)	Are areas adequately illuminated?		IAP	☐	
(**n**)(1)(i)	Is an adequate supply of potable water available?		IAP	☐	
(ii)	Are drinking water containers equipped with a tap?		IAP	☐	
(iii)	Are drinking water containers clearly marked?		IAP	☐	
(iv)	Is a drinking cup receptacle available and clearly marked?		IAP	☐	
(**n**)(2)(i)	Are non-potable water containers clearly marked?		IAP	☐	
(**n**)(3)(i)	Are their sufficient toilets available?		IAP	☐	
(**n**)(4)	Have food handling issues been addressed?		IAP	☐	
(**n**)(6)	Have adequate wash facilities been provided outside hazard zone?		IAP	☐	
(**n**)(7)	If response is greater than 6 months, have showers been provided?		IAP	☐	
4. Prepared By:				**Form SSP-K: Page 3**	

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CG ICS SSP: 1910.120 DRUM COMPLIANCE CHECKSHEET	1. Incident Name	2. Date/Time Prepared	3. Operational Period	4. Safety Officer (include method of contact)
5. Supervisor/Leader	6. Location and Size of Site	7. For Emergencies Contact:		8. Note: tanks and vaults should also be treated in the same manner as described below [1910.120(j)(9)]. Many can also pose confined space hazards.

9. Cite: 1910.120 (Cites that duplicate or explain requirements are omitted)	Requirement	[4]	Comments
(j)(1)(ii)	Drums meet DOT, OSHA, EPA regs for waste they contain, including shipment?	☐	
(iii)	Drums inspected and integrity ensured prior to movement?	☐	
(iii)	Or drums moved to an accessible location (staging area) prior to movement?	☐	
(iv)	Unlabelled drums treated as unknown until properly identified and labeled?	☐	
(v)	Site activities organized to minimize drum handling?	☐	
(vi)	Employers properly warned about the hazards of moving and handling drums?	☐	
(vii)	Suitable overpack drums are available for addressing leaking and ruptured drums?	☐	
(viii)	Leaking materials from drums properly contained?	☐	
(ix)	Are drums that cannot be moved, emptied of contents with transfer equipment?	☐	
(x)	Are suspect buried drums surveyed with underground detection system?	☐	
(xi)	Are soil and covering material above buried drums removed with caution?	☐	
(xii)	Is the proper extinguishing equipment on scene to control incipient fires?	☐	
(j)(2)(i)	Are airlines on supplied air systems protected from leaking drums?	☐	
(ii)	Are employees at a safe distance, using remote equipment, when handling explosive drums?	☐	
(iii)	Are explosive shields in plane to protect workers opening explosive drums?	☐	
(iv)	Is response equipment positioned behind shields when shields are used?	☐	
(v)	Are non-sparking tools used in flammable or potentially flammable atmospheres?	☐	
(vi)	Are drums under extreme pressure opened slowly & workers protected by shields/distance?	☐	
(vii)	Are workers prohibited from standing and working on drums?	☐	
(j)(3)	Is the drum handling equipment positioned and operated to minimize sources of ignition?	☐	
(j)(5)(i)	For shock sensitive drums, have all non-essential employees been evacuated?	☐	
(ii)	For shock sensitive drums: is handling equipment provided with shields to protect workers?	☐	
(iii)	Are alarms that announce start/finish of explosive drum handling actions in place?	☐	
(iv)	Are continuous communications in place between the drum handling site & command post?	☐	
(v)	Are drums under pressure properly controlled for prior to handling?	☐	
(vi)	Are drums containing packaged laboratory wastes treated as shock sensitive?	☐	
(j)(6)(i)	Are lab packs opened by trained and experienced personnel?	☐	
(ii)	Are lab packs showing crystallization treated as shock sensitive?	☐	
(j)(8)(ii-iii)	Are drum staging areas manageable with marked access and egress?	☐	
(iv)	Is bulking of drums conducted only after drum contents have been properly identified?	☐	

10. Prepared By:	**Form SSP-L:**

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7)
Title

F.1.

F.2.

F.3.

F.4.

F.5.

F.6.

F.7.

F.8.

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F.10.

F.11.

F.12.

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F.14.

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F.18.

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ED_001324_00008411-00128

F.19. _____

F.20. _____

F.21. _____

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7)
Sensitive Security Information (SSI)

G.1.

G.1.a.

G.1.a.(1).

G.2.

G.3.

G.4.

G.5.

G.6.

G.7.

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G.9.

G.10.

G.11.

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G.20.a.

G.20.b.

G.20.c.

G.20.d.

G.20.e.

G.20.f.

G.20.g.

G.20.h.

G.20.i.

G.20.j.

G.20.j.(1).

G.20.j.(2).

G.20.j.(3).

G.20.j.(4).

G.21.

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F.16.

G.1.

G.2.

G.3.

G.4.

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