FINAL

Peer Review Summary Report for the External Peer Review of

Dispersant Effectiveness, In-Situ Droplet Size Distribution and Numerical Modeling to Assess Subsurface Dispersant Injection as a Deepwater Blowout Oil Spill Response Option

—and—

Evaluation of Oil Fluorescence Characteristics to Improve Forensic Response Tools

November 18, 2016

Prepared by:

EnDyna, Inc.

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1. INTRODUCTION

The EnDyna Team was tasked with selecting three scientific experts to evaluate the draft final report, *Dispersant Effectiveness, In-Situ Droplet Size Distribution and Numerical Modeling to Assess Subsurface Dispersant Injection as a Deepwater Blowout Oil Spill Response Option—and—Evaluation of Oil Fluorescence Characteristics to Improve Forensic Response Tools*, prepared by the U.S. Environmental Protection Agency (EPA), Office of Research and Development (ORD), and the Department of Fisheries and Oceans Canada (DFO Canada).

The research was funded by BSEE and efforts were partially supported by EPA ORD and the DFO Canada, Bedford Institute of Oceanography. The draft final report summarized two projects that dovetail together regarding differentiating physical from chemical dispersion effectiveness using oil and dispersant injection simulations within a wave tank for improving forensic response monitoring tools. The draft final report is split into tasks based upon the two projects funded by BSEE:

- Task A – *Dispersant Effectiveness, In-Situ Droplet Size Distribution and Numerical Modeling to Assess Subsurface Dispersant Injection as a Deepwater Blowout Oil Spill Response Option*, and

- Task B – *Evaluation of Oil Fluorescence Characteristics to Improve Forensic Response Tools*.

BSEE also provided Appendices A through H as supplementary materials, if needed, to assist the reviewers in providing written comments on Task A and Task B of the draft final report.

In recruiting peer reviewers and coordinating the peer review, the EnDyna Team evaluated the qualifications of peer review candidates, conducted a thorough conflict of interest (COI) screening process, and independently selected the peer reviewers. The EnDyna Team then provided coordination and oversight of the peer review process, and produced this report that summarizes and synthesizes peer reviewer responses.

The sections below describe the EnDyna Team's process for selecting external peer reviewers for Task A and Task B of this draft final report.

1.1 Identification of Experts

The EnDyna Team was tasked with selecting three scientific experts to evaluate BSEE's draft final report. The EnDyna Team conducted an independent search for scientific experts in the following fields of expertise: 1) oil spill dispersants, 2) oil plume and droplet fate and transport, 3) monitoring of oil in water through the use of fluorescence, and/or 4) SMART protocol.

The experts were identified through literature and internet searches of scientific journals, professional societies, universities, scientific meetings, nonprofit organizations, and governmental agencies. Both domestic and international affiliations were considered, as well as affiliations with industry, government, and academia. Examples of organizations or types of individuals contacted or used as a resource include:

- U.S. Coast Guard (USCG); Research and Development Center and Office of Marine Environmental Response Policy
- National Oceanic and Atmospheric Administration (NOAA)
- Environment Canada
- Research organizations (i.e., SINTEF)
- Interspill.org
- International Oil Spill Conference
- University of New Hampshire
- Industry (i.e., Exxon, Shell)
- Independent Consultants
- Recommendations from unavailable experts.

The EnDyna Team received six (6) positive responses from qualified candidates expressing interest and availability to participate in this peer review. The other candidates were either not available during the peer review timeframe or did not respond to our invitation. Interested candidates provided their name, contact information, and curriculum vitae (CV) and/or biographical sketch containing their education, employment history, area(s) of expertise, research activities, recent service on advisory committees, publications, and awards.

1.2 Conflict of Interest Screening Process

The EnDyna Team initiated COI screening on the six interested individuals to ensure that the experts had no COI or appearance of the lack of impartiality. The screening was conducted in accordance with the BSEE Peer Review Process Manual (dated August 2014) and involved each expert completing a COI questionnaire to determine if they were involved with any other work and/or organizations that might create a real or perceived COI for this peer review.

The EnDyna Team received completed COI questionnaires for five (5) candidates and evaluated each expert's professional and financial information. Conflict of interest screening was completed on the five individuals. No real COI issues were identified.

Dr. Tim Nedwed disclosed that he works for industry and leads projects funded by the American Petroleum Institute (API). These are perceived COIs. Perceived COI does not necessarily disqualify an individual from participating, but it is important that any perceived COI is disclosed.

A signed Non-Disclosure Agreement (NDA) was also collected from each reviewer.

1.3 Selection of Candidates

In selecting the peer reviewers, the EnDyna Team evaluated each candidate's credentials to select the experts that, collectively, covered the areas of expertise needed for this peer review, had no real or apparent COI or appearance of the lack of impartiality, and were available to complete the peer review within the desired timeframe. After review and consideration of the available information described above, the EnDyna Team selected four (4) peer reviewers that met those criteria. The names, affiliations, education, and expertise of the four peer reviewers are provided below.

Two of the peer reviewers, Dr. Ali Khelifa and Dr. Fatemeh Mirnaghi, were recommended by Dr. Ben Fieldhouse from Environment Canada as potential reviewers for Task A and Task B of the report, respectively. Because each had specific expertise related to a specific task, these reviewers from Environment Canada were selected to conduct a split review. Dr. Ali Khelifa was selected to review Task A and Dr. Fatemeh Mirnaghi was selected to review Task B of the draft final report. After the split review was approved by BSEE, the EnDyna Team selected three peer reviewers for each of the two tasks in the draft final report.

The three peer reviewers selected for Task A – *Dispersant Effectiveness, In-Situ Droplet Size Distribution and Numerical Modeling to Assess Subsurface Dispersant Injection as a Deepwater Blowout Oil Spill Response Option*, were:

- Lt. Brandon J. Aten,
- Dr. Ali Khelifa, and
- Dr. Tim Nedwed.

The three peer reviewers selected for Task B – *Evaluation of Oil Fluorescence Characteristics to Improve Forensic Response Tools*, were:

- Lt. Brandon J. Aten,
- Dr. Fatemeh Mirnaghi, and
- Dr. Tim Nedwed.

Peer Reviewers Selected by the EnDyna Team:

1.	**NAME:**	Lt. Brandon J. Aten
	AFFILIATION:	U.S. Coast Guard
	EDUCATION:	M.A., Naval War College, 2015 Professional Certificate, Energy Innovation and Emerging Technologies, Stanford University, 2013 B.S., U.S. Coast Guard Academy, Electrical Engineering Systems, 2008
	EXPERTISE:	Lt. Brandon J. Aten graduated from the U.S. Coast Guard Academy in 2008 with a Bachelor of Science in Electrical Engineering. Upon commissioning, he transferred to Honolulu, Hawaii to the Coast Guard Cutter RUSH and served as an engineer and deck watch officer. From there, he transferred to Marine Safety Unit in Port Arthur, Texas, where he served as the Incident Management Division Chief and oversaw the investigation, response, and remediation of oil spills and hazardous material releases. Lt. Aten has extensive operational experience and has supervised over 20 federal oil spill and hazardous material cases worth $14.2 million, including the recent Hurricane Sandy. Currently, Lt. Aten serves as Program Manager, Office of Marine Environmental Response Policy, where he manages the development, coordination, and integration of

	strategic planning policy for Marine Environmental Response contingencies and serves as the USCG Marine Environmental Response technical advisor to various national and international groups and associations. Lt. Aten also currently serves as Situation Unit Leader for the specialized Atlantic Area Incident Management Team. When assigned to an incident, he supports the operational commander in complex incident/crisis management for all-hazard, all threat incidents and events. The Atlantic Area Incident Management Team is a rapidly deployable, scalable resource that addresses capability gaps within an incident management organization wherever required.

2.	**NAME:**	Dr. Ali Khelifa
	AFFILIATION:	Environment Canada
	EDUCATION:	Ph.D., Laboratory Modeling, Environmental Hydraulics Department of Civil Engineering, Laval University, Québec, Canada, 1998 M.Sc., Computer Modeling, Environmental Hydraulics Department of Civil Engineering, Laval University, Québec, Canada, 1992 Engineer Diploma, Hydraulic Engineering, National High School of Hydraulics, Algiers, Algeria, 1989
	EXPERTISE:	Dr. Ali Khelifa is currently Research Scientist (Spill Modeler) and Head of the Spill Modeling Unit, for the Emergency Science and Technology Section, Water Science and Technology Directorate, Science and Technology Branch, Environment Canada. He develops Environment Canada's research and operational capabilities to provide scientific support nationwide and on a 24/7 basis on modeling of the transport and fate and behavior of hazardous substances spilled in the environment. Previously, Dr. Khelifa was Research Scientist (Spill Modeler) at the Centre for Offshore Oil and Gas Environmental Research, Bedford Institute of Oceanography, DFO Canada. He conducted field and numerical investigations of environmental impacts of production wastes from offshore oil and gas exploitation in the Scotian shelf and the Gulf of the St. Lawrence. Dr. Khelifa also worked for many years as an Expert Consultant (Spill Modeler) and researcher. Dr. Khelifa's areas of expertise are: • Laboratory and numerical modeling of oil and chemical spills • Oil-sediment interaction • Oil-turbulence interaction • Oil-dispersant interaction • Oil-ice interaction • Sediment transport • Hydrodynamic modeling • Water quality modeling

	• Groundwater quality modeling • Air quality modeling • Fire modeling • Explosion modeling • Stochastic modeling • Risk assessment and consequence analyses.

3.	**NAME:**	Dr. Fatemeh Mirnaghi
	AFFILIATION:	Environment Canada
	EDUCATION:	Postdoctoral Fellow, Centre for Cellular and Biomolecular Research, University of Toronto, 2013-2014 Ph.D., Analytical Chemistry, Department of Chemistry, University of Waterloo, Waterloo, Canada, 2013 M.S., Analytical Chemistry, University of Tehran, Iran, 2005 B.S., Applied Chemistry, University of Giulan, Rasht, Iran, 2003
	EXPERTISE:	Dr. Fatemeh Mirnaghi is currently Oil Research Scientist, for the Emergency Science and Technology Section, Water Science and Technology Directorate, Science and Technology Branch, Environment Canada. Recent projects include: • Developed a finger printing method for rapid analysis of polyaromatic hydrocarbons (PAH) in environmental spilled oils using fluorescence spectroscopy coupled with parallel factor analysis (MATLAB) and principle component analysis. • Developed and evaluated a novel approach for fractionation of total petroleum hydrocarbons (TPH) in crude oils (F1-F8). • Evaluated the distribution of TPH and PAH of crude oil in contact with salt water in a simulation study of oil spills. • Analyzed physiochemical properties of the crude oils and prepared a universal database. In addition to experimental design, data analysis, statistical analysis, data interpretation, and report writing, Dr. Mirnaghi's areas of technical expertise are: • Liquid chromatography (LC), Mass spectrometry (MS), Gas chromatography (GC), LC-MS/MS, Direct analysis in real time (DART), Fluorescence spectroscopy, UV-VIS, X-ray diffraction spectroscopy, Scanning electron microscopy, Nuclear magnetic resonance (NMR). • Solid phase microextraction (SPME), Solid phase extraction (SPE), Liquid-liquid extraction, Solvent extraction, Column chromatography, Extracted blood spot (EBS) sampling, Dried blood spot sampling (DBS), Complex biofluids and food analysis, Drug and small molecules analysis, Metabolomics studies, Oil analysis, Physical properties (densitometry, viscometry, surface tension analysis, flash point and pour point analysis).

4.	**NAME:**	Dr. Tim Nedwed, P.E.
	AFFILIATION:	ExxonMobil Upstream Research Company
	EDUCATION:	Ph.D., Environmental Engineering, University of Houston, 1996 M.S., Environmental Engineering, University of Houston, 1992 B.S., Chemical Engineering, University of Kansas, 1987
	EXPERTISE:	Dr. Tim Nedwed is the Oil Spill Response Senior Technical Professional with ExxonMobil Upstream Research Company (URC). He has worked for ExxonMobil for 16 years. He has led the URC oil spill response research program for the last 10 years. Dr. Nedwed's primary expertise is oil spill response technologies with a focus on dispersants, in-situ burning, remote detection of oil, and oil spill fate and effects. He has developed a new dispersant formulation, new insights on how dispersants work, methods of applying dispersants in the Arctic and subsea, and new methods for applying in-situ burning. Currently, Dr. Nedwed is developing a technique to detect oil under ice using nuclear magnetic resonance and a one-step skimmer-burner system to enhance in-situ burning. He is frequently invited to speak on these topics at external forums and has presented at numerous oil spill and general industry conferences. Dr. Nedwed has also conducted research on well containment/control and deepwater oil and gas development. The achievements of Dr. Nedwed were recognized by ExxonMobil's URC when he received the 2010 ICE award for outstanding innovation and creativity. In addition, Dr. Nedwed received the prestigious 2013 Edith and Peter O'Donnell Award for Technology Innovation given by the Academy of Medicine, Engineering, and Science of Texas.

This peer review report is comprised of Sections 2, 3, 4, 5, and 6. ***Section 2*** provides the charge questions sent to each of the peer reviewers for comments, ***Section 3*** provides the synthesis of their peer review comments, and ***Section 4*** provides the peer review comments of each reviewer organized by charge question. In addition, ***Section 5*** (Appendix A) consists of the individual peer reviewers' comments. The peer review materials packages in ***Section 6*** (Appendix B) are attached separately.

2. CHARGE QUESTIONS

The purpose of this review was to obtain written comments from individual experts on the research report entitled, *Dispersant Effectiveness, In-Situ Droplet Size Distribution and Numerical Modeling to Assess Subsurface Dispersant Injection as a Deepwater Blowout Oil Spill Response Option—and—Evaluation of Oil Fluorescence Characteristics to Improve Forensic Response Tools*. Each reviewer was charged with evaluating the report, providing their overall impressions of the scientific merit of the report, responding to eight charge questions, and providing any other specific comments on the report. The eight charge questions provided to the reviewers are presented below.

1	Are the objectives and relevance of the Task A study clearly defined? If not, what are your recommendations for improving the description of the Task A study's objectives and relevance?
2	Were the methods used for the Task A oil dispersion experiments conducted in the flow-through wave tank (flume) facility clearly described, properly implemented, and appropriate for evaluating deepwater blowouts?
3	Were the results of the sampling as well as the dispersant effectiveness and droplet size distribution analyses in Task A adequately characterized and clearly described? Are the conclusions drawn from the dispersant effectiveness and droplet size distribution analyses logical and appropriate based on the results? Are there any additional conclusions that could be drawn?
4	Does the discussion in Task A of the report about experimental results along with the results from numerical modeling using data obtained from the experiments present sufficient new data and knowledge, and are the findings useful for informing oil spill response planning for deepwater blowouts?
5	Are the objectives and relevance of the Task B study clearly defined? If not, what are your recommendations for improving the description of the Task B study's objectives and relevance?
6	Were the methods used for evaluation of oil fluorescence characteristics and sensor performance in the Task B wave tank experiments adequately characterized and clearly described?
7	Are the Task B conclusions logical and appropriate based on the results of the wave-tank based and laboratory-based experiments using different oil types and dispersant-to-oil (DOR) ratios? Were there any critical results not discussed or addressed in Task B of the report?

8	Does the discussion in Task B of the report about the evaluation of sensor performance present sufficient new data and knowledge, and are the findings useful for improving the interpretation of field fluorescence data and informing decision-making during oil spill response planning (e.g., selection of optimum sensor configuration for submersible fluorometers)?

3. SUMMARY OF PEER REVIEWERS COMMENTS

The section below provides the synthesis of peer reviewers' comments, including general impressions and responses to charge questions.

3.1 General Impressions

Two peer reviewers, Lt. Brandon J. Aten and Dr. Tim Nedwed, reviewed both Task A and Task B of the draft final report. The peer reviewers from Environment Canada conducted a split review, based on their areas of expertise, with Dr. Ali Khelifa reviewing Task A and Dr. Fatemeh Mirnaghi reviewing Task B of the draft final report.

General Impressions for Task A: *Dispersant Effectiveness, In-Situ Droplet Size Distribution and Numerical Modeling to Assess Subsurface Dispersant Injection as a Deepwater Blowout Oil Spill Response Option*

The following general impressions were provided for Task A of this study. The three peer reviewers for Task A (Lt. Brandon J. Aten, Dr. Ali Khelifa, and Dr. Tim Nedwed) provided general impressions on presentation of the draft final report, experimental procedures/protocol, the modeling in several appendices, and the accuracy of results and conclusions.

<u>Presentation</u>

Two of the three peer reviewers who reviewed the Task A study commented favorably on the presentation of the draft final report,[1,BA; 2,TN] while the other reviewer commented that revisions were needed.[AK]

One reviewer stated that overall the report was well written and thorough.[TN] Another reviewer commented that the report adequately addressed the project tasking and associated objectives. This reviewer also stated that for certain Task A objectives with respect to dispersant effectiveness being measured as a shift in droplet size distribution (DSD), the findings presented in the report were useful for informing oil spill responders and planners about what subsea response operation conditions (types of dispersant, oil types, dispersant-to-oil ratio (DOR), water temperature) could help in decision-making about a preferred response option during subsea blowouts.[BA]

While another reviewer agreed that the information presented seemed to be in line with the objectives of the project, this reviewer suggested that the presentation and discussions of the data and related uncertainty needed revision. This reviewer acknowledged that the report included an extensive series of data on size distribution of oil droplets generated from submerged jet experiments in a tank under various conditions.[3,AK]

[1] BA = Lt. Brandon J. Aten
[2] TN = Dr. Tim Nedwed
[3] AK = Dr. Ali Khelifa

Experimental Procedures/Protocol

Two of the three peer reviewers who reviewed the Task A study commented on the experimental procedures or protocol, with one commenting favorably[BA] and the other reviewer describing significant concerns. [TN] One of those reviewers commented that the stated techniques and procedures within the draft final report regarding the facility (flume) and the subsurface oil injection system were clearly articulated and implemented.[BA]

One of those reviewers described several significant concerns regarding the experimental protocol for Task A. This reviewer emphasized that all of those issues challenged the value of the Task A study. [TN] Issues identified by this reviewer are summarized below:

- First, the reviewer noted that the discharges were in a shallow tank with a current and that one goal was to measure the DSD of the rising plume with instruments placed down current. The reviewer stated that the challenge with this experimental protocol was that buoyant droplets could rise above the measurement device before measurements could be taken. The reviewer also stated that droplets will vertically partition in the plume regardless. This reviewer calculated that the rise velocities indicated that crude oil droplets significantly greater than 100 microns could rise too fast to be detected by the first LISST (Laser In-Situ Scattering and Transmissometry) instrument located 5.1 meters down current of the release point in a current of 1 cm/s. This reviewer observed that the report did not include description of the method used by the researchers to measure large droplets. Unless the researchers had some method for measuring large droplets, then the reviewer argued that the Task A results were all biased away from large droplets that likely were generated when dispersants were not used. The reviewer commented that this was a critical issue that must be addressed in the report, and furthermore if it was not actually addressed in the Task A study then the reviewer concluded that the value of the Task A study was very suspect.

- Second, the reviewer commented that the bimodal distribution for DSD found for the high DOR tests with crude oils could be an artifact of the LISST instrument. The reviewer explained that the LISST has a Path Reduction Module (PRM) for use in high concentrations of particles/droplets, which is used to increase the amount of laser light that penetrates to the detector. The reviewer noted that the LISST instrument manufacturer has stated that the amount of laser light penetrated needs to be above 40%; therefore, if the Task A study obtained less than 40% light penetration, either with or without the PRM, then the bimodal distribution could be an instrument bias. Additionally, the reviewer commented that even penetration of less than 60% could be an issue. The reviewer argued that if this was an artifact of the LISST instrument, the data obtained in Task A was biased toward small droplets that may not have existed or existed at the high concentrations observed in the experiments.

- Third, the reviewer observed an issue with measuring interfacial tension between oil and seawater in the tank, based on the data this reviewer found in Table 3 of Appendix H. The data in the column for oil-water interfacial tension (IFT) for untreated oil appeared too high, and the reviewer suggested referring to prior measurements found in the Environment

Canada database (http://www.etc-cte.ec.gc.ca/databases/OilProperties), which has data on Alaskan North Slope (ANS) and South Louisiana Crude (SLC) oils.[TN]

Modeling in Appendices

One reviewer identified several inconsistencies between the draft final report and the modeling components presented within Appendix G and Appendix H. This reviewer suggested providing clarification about these issues, as summarized below.[AK] It is important to note that Appendix G and Appendix H as well as the other appendices were provided to the peer reviewers as supplementary materials.

The reviewer stated that the modeling component presented in Appendix G was not related to the series of tank experiments presented in the draft final report and Appendices A through E. The reviewer commented that the work presented in Appendix G was a relatively simplistic study of how the commercial computational fluid dynamics (CFD) software Fluent, and in-house models, were used to illustrate jet flow modeling to predict transport of positively buoyant oil droplets. This reviewer stated that the comparison with the results observed in Appendix G was very limited and that the presentation of the results needed revision. The reviewer did not identify any clear link between the study in Appendix G and the overall project objectives listed on page 17 of the draft final report.[AK]

This reviewer also commented that the modeling component presented in Appendix H had no clear purpose and that it seemed related to work conducted for the study in Appendix G. This reviewer noted that both of the modeling studies presented in Appendix G and Appendix H deal with prediction of DSD; however, the model presented in Appendix H focused on predicting DSD far from the jet (equilibrium), while the model in Appendix G included prediction of DSD anywhere downstream from the jet. Additionally, the reviewer commented that it was confusing that the VDROP-J model was used to predict DSD in Appendix G, but the Modified Weber Number Approach was used in Appendix H due to its simplicity, as compared to the Maximum Entropy Formalism Approach and the approach used in the VDROP-J model. The reviewer also stated that more clarification was necessary for experimental data for DOR of 1:250 and 1:25 within Appendix H, as that data was not discussed or presented in the draft final report.[AK]

Accuracy of Results and Conclusions

Two of the three reviewers who reviewed the Task A study commented on the accuracy of the results and conclusions. One of those reviewers was generally favorable,[BA] while the other reviewer commented that bias in the Task A results was a critical issue that needed attention.[TN]

One reviewer stated that while several variables associated with determining dispersant effectiveness were technically evaluated, and although other potential variables exist, the reviewer believed that the accuracy of the information and the soundness of the conclusions stood firm. This reviewer added that overall the report for Task A stood firm in its conclusions and stated that it would serve, along with Task B, as an excellent backbone to ongoing research about subsea oil spill response.[BA]

As summarized above (see Experimental Procedures/Protocol), one reviewer observed that unless the researchers had some method for measuring large droplets, then the reviewer argued that the Task A results were all biased away from large droplets that likely were generated when dispersants were not used. The reviewer commented that this was a critical issue that must be addressed in the report, and furthermore if it was not actually addressed in the Task A study then the reviewer concluded that the value of the Task A study was very suspect.[TN]

General Impressions for Task B: *Evaluation of Oil Fluorescence Characteristics to Improve Forensic Response Tools*

The following general impressions were provided for Task B of this study. The three peer reviewers for Task B (Lt. Brandon J. Aten, Dr. Fatemeh Mirnaghi, and Dr. Tim Nedwed) provided general impressions for Task B on methodology and experimental protocol as well as results and conclusions.

Methodology and Experimental Protocol

Two reviewers commented favorably overall about the methodology or experimental protocol for the Task B study.[4,FM; TN] One reviewer stated that the Task B study generally used proper methodology and approach for evaluation of optimum fluorescence wavelengths for oil detection (as a function of oil type and DOR) to assist responders in selecting proper sensors and establishing best practices for rapid decision-making during oil spill response.[FM] Another reviewer commented that there were no significant issues regarding the experimental protocol for Task B. This reviewer's comment about Task B was made in comparison to several significant issues this reviewer had identified with the experimental protocol for Task A (see above).[TN]

With respect to the Excitation Emission Matrix Spectroscopy (EEM) - Parallel Factor Analysis (PARAFAC), or EEM-PARAFAC modeling, one reviewer noted that a substantial portion of the data included was pre-validation results for a model that could have not been validated. This reviewer strongly recommended that these detailed discussions should be entirely removed from the main report or transferred to supplementary data to prevent confusion about the modeling approach.[FM]

Results and Conclusions

One reviewer that had stated the Task B study generally used proper methodology and approach (see above) also commented that the information presented for the evaluation of optimum fluorescence wavelengths for oil detection seemed accurate. However, this reviewer argued that major revision of the report was necessary because the report was mainly presentation of experimental results and numerical modeling without adequate discussion, explanation, and interpretation of results, or conclusions based on observed data. This reviewer specifically mentioned, as an example, the results from comparison of EEM results with gas chromatography (GC) data and EEM-PARAFAC modeling. This particular comparison represented a large amount of data without including sufficient discussion on the reasons for observed results, or providing conclusions from this data. Additionally,

[4] FM = Dr. Fatemeh Mirnaghi

with respect to the Task B objectives, the reviewer observed no conclusions that discussed how the results could work as a response tool that would assist responders for rapid decision-making during oil spill response.[FM]

Another reviewer commented overall that the report for Task B stood firm in its conclusions and stated that it would serve, along with Task A, as an excellent backbone to ongoing research about subsea oil spill response.[BA]

3.2 Responses to Charge Questions

The section below provides the synthesis of the peer reviewers' comments, concerns, and suggestions regarding the charge questions.

1	*Are the objectives and relevance of the Task A study clearly defined? If not, what are your recommendations for improving the description of the Task A study's objectives and relevance?*
Comments:	Two reviewers agreed that the objectives and relevance of the Task A study were clearly defined.[AK,TN] One reviewer stated simply that the objectives were clearly defined.[TN] One reviewer stated that the information presented in the report was in line with the objectives of the project.[AK] Another reviewer commented that the relevance of Task A was clearly articulated and defined; however, this reviewer provided examples of inconsistencies that should be addressed for clarification of the Task A objectives.[BA] With respect to the relevance of Task A, one reviewer commented that reports like the Task A study are vital for oil spill response planning, given the history of subsea dispersants. This reviewer stated that understanding methods for evaluation of subsea dispersant effectiveness, along with understanding what influences these operations, was fundamental to the pre-planning and operational risk assessment process. This reviewer suggested that the International Oil Spill Conference (IOSC) report, "Subsea Monitoring and Analytical Results: Subsea Dispersed Oil, MC252 Deepwater Horizon Release" (Johns, Beckmann), was an additional and useful reference on the history of the Deepwater Horizon subsea dispersant program.[BA] This reviewer commented that clarification of the Task A objectives was needed because the reviewer observed inconsistencies within the report in defining the project objectives for Task A. This reviewer provided examples from the report from pages 3 and 17, as described below, to convey this point. The reviewer recommended more clarification between goals, objectives, and research strategies throughout the Task A report. More specifically, this reviewer noted that on page 3, the report stated that the main objectives of Task A were to evaluate high speed subsurface releases of physically and chemically dispersed oil using a flow-through wave tank/flume facility. This reviewer noted that this statement about the main objective was

1	*Are the objectives and relevance of the Task A study clearly defined? If not, what are your recommendations for improving the description of the Task A study's objectives and relevance?*
	followed by three related issues, which appeared to be specific objectives: 1) "Performance evaluation of dispersants for subsurface injection into sub-sea blowouts; 2) Tracking, modeling, and predicting the movement and spread of the deepwater plume and oil surfacing from deepwater blowouts; and 3) Evaluating the influence of dispersant applications in reducing the concentration of volatile organic compounds emanating from the water surface." Furthermore, this reviewer described more inconsistencies by providing a comparison to other information on page 17, where the objectives for Task A were defined (and the word "objectives" was bolded and underlined): 1) "Refine existing equipment, technologies, and methodologies for subsurface dispersant application assessment and monitoring by measuring dispersed oil concentration, fluorescence, and in-situ oil droplet size distribution; 2) Evaluate effects of water temperature and dispersant on dispersion efficacy and dispersed oil droplet size distribution of oil at high temperatures; 3) Evaluate dispersion effectiveness as a function of oil type and DOR for deepwater blowout spill response; 4) Assess the effect of dispersant application on the VOC concentration in air above the air-sea interface of the wave tank; and 5) Integrate droplet size distribution into deepwater blowout transport/behavior models to enable prediction of the dispersed oil droplets under high flow velocities in deepwater blowouts."[BA] One reviewer added a comment that was not intended to necessarily be considered within the report, but provided as a recommendation to be added within additional materials (e.g., factsheets, expanded summaries) that might be developed. The reviewer suggested linking each finding with a specific task (A or B) and/or objective. To illustrate this recommendation, the reviewer provided an example of a linking suggestion: "Addition of either Corexit 9500 or Finasol OSR 52 chemical dispersants to Alaskan North Slope (ANS), IFO 120 and South Louisiana Crude (SLC) oils decreased the Volume Mean Diameter (VMD) and shifted the Droplet Size Distribution (DSD) to smaller droplets. In general, Corexit 9500 produced smaller droplets compared to Finasol OSR 52." (Task A, Objective 1).[BA]

2	*Were the methods used for the Task A oil dispersion experiments conducted in the flow-through wave tank (flume) facility clearly described, properly implemented, and appropriate for evaluating deepwater blowouts?*
Comments:	The reviewers provided overall comments that were wide ranging with respect to the methods used for the Task A oil dispersion experiments conducted in the flow-through wave tank (flume) facility. These overall comments are summarized below, ranging from disagreement to agreement that the methods were clearly described, properly implemented, and appropriate for evaluating deepwater blowouts: • One reviewer stated that unless additional detail was available to explain the experimental methods (i.e., how observations of fast-rising oil droplets were made), this reviewer believed that the Task A methods were not adequate for evaluating deepwater blowouts.[TN] • Another reviewer raised numerous methodological questions, indicating that the Task A experimental methods could have been described more clearly or implemented differently.[AK] • In contrast, another reviewer stated that overall the methods were clearly described, referenced, and implemented. As an example, this reviewer mentioned the background scatter files, which served as an important baseline for later data files. This reviewer believed that the research team expertly executed the methods to accurately assess Task A objectives, despite inherent difficulties that exist when attempting to simulate and evaluate deepwater blowouts (e.g., due to environmental variances such as DOR and oil type). This reviewer, however, also raised some questions related to the methods.[BA] Two reviewers posed similar questions with regard to the frequency and consistency of tank cleaning after each experiment.[BA,AK] One reviewer acknowledged that the report mentioned cleaning the entire subsurface injector system by flushing with toluene, acetone, and fresh water prior to the next experiment. The reviewer inquired about the duration of each flushing, and whether the flushing procedure was done consistently with each cleaning. This reviewer was also interested in more information about the existence of any associated standards and procedures for the cleaning method.[BA] The other reviewer questioned whether the tank was emptied and cleaned from oil after each run (i.e., oil injection) when conducting the triplicate experiments. This reviewer suggested that more information should be provided about tank cleaning, and if this cleaning was not done, the reviewer suggested that information should be provided about how the experimental methods addressed contamination from previous test runs.[AK]

2	*Were the methods used for the Task A oil dispersion experiments conducted in the flow-through wave tank (flume) facility clearly described, properly implemented, and appropriate for evaluating deepwater blowouts?*
	Two reviewers had specific questions regarding instrumentation procedures of the Task A study.[BA,TN] One reviewer stated that the bimodal distribution for DSD found for the high DOR tests with the crude oils could be an artifact of the LISST instrument. The reviewer stated that the LISST has a PRM for use in high concentrations of particles/droplets, which increases the amount of laser light that penetrates to the detector. The reviewer explained that the manufacturer has stated that light penetration must be above 40%. If the Task A method obtained less than 40% light penetration, either with or without the PRM, then the bimodal distribution associated with the high DOR tests could be a result of instrument bias. The reviewer added that even light penetration less than 60% may be an issue.[TN] Another reviewer questioned whether instrument drift was checked after each testing session.[BA] One reviewer observed that the nozzle release diameter impacted droplet sizes, because initial droplet formation was a function of release diameter along with other factors. For example, the assembly to a nozzle (2.4 mm inner diameter) required for scaling as a full-scale discharge could be greater than 20-40 cm in diameter. Smaller discharge orifices limit the size of droplets, both with and without dispersant. During tank experiments, however, small discharge orifices are often used and even required to limit the mass loading of oil into the flow tank. The reviewer commented that it may be worth mentioning the following statements within the analysis: "In subsurface injection jet experiments, that range of diameters is narrower, where particles > 100µm were not observed. This suggests that the combination of chemical dispersant, elevated turbulence mixing from the jet release and higher oil temperature of 80°C yielded smaller droplets. To discern the dominant factor controlling the difference, additional testing would need to be conducted."[BA] Another reviewer expressed various concerns regarding experimental methods and results from the "triplicate experiments," where each treatment was used to evaluate dispersant effectiveness (i.e., dispersant effects on DSD). The reviewer questioned how the experiments were considered as "triplicate." This reviewer noted, based on information listed in Tables A1 to A8 in Appendix A, that some of the triplicate experiments were run on the same day with relatively the same conditions, while other experiments were run on different days under different conditions. The reviewer also noted that the particle size distributions and volume mean diameter (VMD) data presented in the draft final report (e.g., Figures 5, 6, 8, 9, 10, 12, 13, 16) were selected from the results of the triplicate experiments. The reviewer inquired about the criteria used, for example, to select these particle size distributions and VMD data to

2	*Were the methods used for the Task A oil dispersion experiments conducted in the flow-through wave tank (flume) facility clearly described, properly implemented, and appropriate for evaluating deepwater blowouts?*
	demonstrate the effect of DOR.[AK] The same reviewer questioned why experiments with IFO-120 and Finasol OSR S2 at DOR 1:200, 1:100, and 1:20 were not run in triplicate. This reviewer also questioned how the results from the "triplicate experiments" for each treatment were used to evaluate quantitatively the uncertainty of dispersion efficacy.[AK] This reviewer commented that the amount of oil used in the experiments was not kept constant or relatively close, and also commented that Appendix C showed the amount varying from 132g to 380g. The reviewer stated that this was significant and that it may have caused significant effects on the Task A results. The reviewer emphasized that the Task A report should discuss this variation in details and its contribution to variants observed in the results (e.g., size distribution, VMD, and total particle concentration (TPC)).[AK] The reviewer pointed out that the last paragraph on page 18 of the draft final report mentioned that "Water current velocities were measured at various depths and locations in the tank." The reviewer observed no such results presented in the report. The reviewer recommended adding the complete illustration of the vertical and horizontal profiles of the water current velocity data measured at different locations of the tank. The reviewer stated that information related to the statement on page 19, "horizontal water current velocities that were consistent at all measured depths," should also be illustrated as key information for understanding transport of the droplet plume.[AK] The reviewer also stated that the ways the experiments and data for cold/warm water were presented and discussed were misleading. The reviewer stated that this may lead to misinterpretation of the effects of temperature on the processes studied. The reviewer recommended that the entire classification of the experiments vis-à-vis water temperatures and related discussions of data should be reviewed. For example, the reviewer noted: 1) In Table A1 to A8 in Appendix A, the range of cold water temperatures was 5.4-11.4 ^{o}C and 4.9-13.2 ^{o}C for ANS/Corexit 9500 and IFO-120/Corexit 9500, respectively. 2) According to the delineations above, all the experiments conducted with Gas Condensate/Corexit 9500 fall under the category of cold water, and not warm water as mentioned in Table A5. 3) The discussions of the data for ANS and IFO-120 presented in the second paragraph on pages 35 and 49, respectively, were not consistent

2	*Were the methods used for the Task A oil dispersion experiments conducted in the flow-through wave tank (flume) facility clearly described, properly implemented, and appropriate for evaluating deepwater blowouts?*
	with the limits mentioned above. For ANS (page 35), warm and cold waters were defined by water temperatures ≥ 11 ^{o}C and ≤ 10 ^{o}C. For IFO-120 (page 49), cold water experiments were identified by those run at water temperatures that ranged between 4.9-7.5 ^{o}C, which was not consistent with the classification shown in Table A2. In Table A2, the water temperatures ranged between 4.9-13.2 ^{o}C instead. Although this was discussed briefly in the last paragraph in page 50, the problem with the classifications of the experiments was also obvious in other series as mentioned above.[AK] Finally, one reviewer observed there might be some discrepancies between the draft final report and Appendix H. As described on page 30, the flow system in the tank was kept running for a 12-minute time period during the measurements, but switched from recirculation mode to flow through mode. The reviewer stated that Appendix H indicated that the flow in the tank was 600 gpm, and with this flow rate, water depth would have been reduced by 1.4 meters during the 12-minute time period used to take measurements. The reviewer emphasized that any differences between the information presented in the report and the appendices needed either greater clarity or, if relevant, more consistency. The reviewer also suggested that the Task A study should explain and demonstrate how the flow through affected water depth in the tank, and the experiments overall.[AK]

3	*Were the results of the sampling as well as the dispersant effectiveness and droplet size distribution analyses in Task A adequately characterized and clearly described? Are the conclusions drawn from the dispersant effectiveness and droplet size distribution analyses logical and appropriate based on the results? Are there any additional conclusions that could be drawn?*
Comments:	The reviewers varied in their comments about the characterization and description of the results for the Task A study. One reviewer stated that overall, the conclusions drawn concerning dispersant effectiveness and DSD were sound, because the QC steps were clearly defined for the LISST and in-situ fluorometers in terms of outliers and preventative measures.[BA] One reviewer had numerous concerns and questions, indicating that the results of the sampling as well as the dispersant effectiveness and DSD analyses in Task A could have been described more clearly or categorized more effectively.[AK] Another reviewer stated that the DSD analyses may not have been adequately characterized, as this reviewer explained in more detail under Charge Question #2 and Specific Observations as well as General Impressions.[TN] In addition to DSD analyses, the reviewers commented on ANS dispersion

3	*Were the results of the sampling as well as the dispersant effectiveness and droplet size distribution analyses in Task A adequately characterized and clearly described? Are the conclusions drawn from the dispersant effectiveness and droplet size distribution analyses logical and appropriate based on the results? Are there any additional conclusions that could be drawn?*
	effectiveness, IFO-120 dispersion effectiveness, VOC air monitoring, and LISST. <u>DSD Analyses</u> Two reviewers commented that DSD may not have been adequately characterized in the Task A study.[AK,TN] One reviewer commented that assessing dispersant effectiveness based on measurements of DSD in one location in the tank in most of the experiments was not sufficient. The reviewer emphasized that because assessment of dispersant effectiveness was related to the ability to minimize coalescence of small droplets initially formed, DSD measured with downstream LISST should be shown in Appendix C and presented alongside DSD measured with Jet Release LISST (presented in Appendix C). The reviewer was surprised that the Task A study presented all of the data obtained with Jet Release LISST in Appendix C, but only a few from the Downstream LISST (Figures 13 and 20).[AK] As summarized above under Charge Question #2, one reviewer stated that the bimodal distribution for DSD found for the high DOR tests with the crude oils could be an artifact of the LISST instrument. The reviewer stated that the LISST has a PRM for use in high concentrations of particles/droplets, which increases the amount of laser light that penetrates to the detector. The reviewer explained that the manufacturer has stated that light penetration must be above 40%. If the Task A method obtained less than 40% light penetration, either with or without the PRM, then the bimodal distribution associated with the high DOR tests could be a result of instrument bias. The reviewer added that even light penetration less than 60% may be an issue.[TN] <u>ANS Dispersion Effectiveness</u> One reviewer stated that highlighting the DSD for ANS dispersion effectiveness, irrespective of water temperature or added dispersant, was important element for responders to comprehend. The reviewer commented that the results for ANS dispersion effectiveness were strongly formed with supporting figures. While the reviewer was unclear if the differentiation between warm (>11 °C) or cold (<10 °C) water temperature was based on other references or planned for these experiments, the reviewer noted this could be used to create a baseline for future experimentation.[BA]

3	*Were the results of the sampling as well as the dispersant effectiveness and droplet size distribution analyses in Task A adequately characterized and clearly described? Are the conclusions drawn from the dispersant effectiveness and droplet size distribution analyses logical and appropriate based on the results? Are there any additional conclusions that could be drawn?*
	IFO-120 Dispersion Effectiveness Two reviewers commented on the IFO-120 dispersion effectiveness.[BA,AK] One reviewer stated that while the effects of water temperature on dispersibility of ANS/Corexit 9500 were discussed on page 37 and in figures 14 and 15, the reviewer recommended that the Task A study also discuss these effects on dispersibility of IFO 120/Corexit 9500 for 1:20 DOR.[AK] Another reviewer stated that the smaller VMD values for specific treatments (DOR 1:20) validated dispersion effectiveness as indicated by the displayed shift in DSD. While the shift was to a lesser extent than ANS, the reviewer stated that this can be attributed to the viscosity of IFO-120. Similar to ANS, the reviewer commented that the conclusions were displayed efficiently. The reviewer stated that information noted on page 59 of the draft final report — "This suggests that the combination of chemical dispersant, elevated turbulence mixing from the jet release and higher oil temperature of 80 °C yielded smaller droplets." — was of particular interest to responders in terms of observing what factors yield smaller droplets.[BA] VOC Air Monitoring One reviewer inquired whether a majority of the instrument error was based strictly on the downstream volatile organic compound (VOC) monitor. If this occurred in the experiments, the reviewer commented that it was important to illustrate that the VOC monitor at the jet release point was unaffected. While the reviewer stated that all VOC monitor locations were important with respect to oil spill response, the jet release point was of particular importance due to the immediate location of platform operations.[BA] LISST One reviewer commented extensively on LISST instrumentation, data collection and presentation, and results. The reviewer stated that VMD had several names/formulations, including D[4,3] and D[3,0]. The reviewer recommended adding explanation of how VMD was calculated in the Task A study. This reviewer questioned why sampling of DSD with LISST was not performed after homogeneity was reached in the tank (i.e., 45 minutes after each oil addition) as explained on page 31 of the draft final report.[AK]

3	*Were the results of the sampling as well as the dispersant effectiveness and droplet size distribution analyses in Task A adequately characterized and clearly described? Are the conclusions drawn from the dispersant effectiveness and droplet size distribution analyses logical and appropriate based on the results? Are there any additional conclusions that could be drawn?*
	With respect to the fifth line in the first paragraph of page 32 of the draft final report, the reviewer commented that the approach used to identify and remove outliers from the LISST data consisted of removing: ". . . any reading that is greater than the moving mean of the dataset . . . multiplied by four times the standard deviation. . .". The reviewer stated that this approach was questionable and should be supported by peer-reviewed references. This reviewer believed that apparently the Task A study used the "Rule of Huge Error" (the reviewer's term) to detect and eliminate outliers from the LISST data, and as such, suggested that the statement should instead say: ". . . the dataset plus four times the standard deviation."[AK] The reviewer commented that water samples were taken from the same location as the LISST sampling locations, with total petroleum hydrocarbon (TPH) analysis performed on these samples. The reviewer stated that while some work was done to compare (calibrate) data from different fluorometers, as well as the TPH data extracted from the water samples (pages 66-99), there was a lack of comparison between LISST results and the water sample analysis. The reviewer indicated this lack of comparison was surprising, considering the fact that there was a link between the TPC measured by LISST and TPH measured from the water samples. In other words, the reviewer questioned why TPH analysis was not used to attempt to validate TPC data measured by LISST. The reviewer specifically mentioned a confusing statement on page 66 of the draft final report: "… oil concentrations within the bottles represent an average over a 30 second time period that cannot be aligned with the time series data which is generated on the time scale of seconds." The reviewer suggested that, via integration, the comparison of oil concentration from water samples (bottle) and the time series from LISST and fluorometers was possible.[AK] The reviewer commented that one of the major concerns about the data presented in the Task A study related to the LISST data for particle sizes of 2.5-3.0 µm. The reviewer pointed out in the second paragraph on page 26 of the draft final report, that the instrument measured particle sizes in the range of 2.5-500 µm. The reviewer commented that the data for many size distributions at 2.5 and 3.0 microns, especially at DOR of 1:20 (e.g., Figures C4 and C8), have large uncertainties and may bias the VMD calculations; however, this limitation was not discussed in the report. The reviewer highly recommended that the Task A study provide detailed discussion of the limitations of the LISST measurement for droplet size in lower range of 2.5-

3	*Were the results of the sampling as well as the dispersant effectiveness and droplet size distribution analyses in Task A adequately characterized and clearly described? Are the conclusions drawn from the dispersant effectiveness and droplet size distribution analyses logical and appropriate based on the results? Are there any additional conclusions that could be drawn?*
	3.5 µm and how that limitation affected the uncertainty of the results obtained for size distributions and related VMDs. For example, the reviewer recommended having two LISST instruments validated using certified micro particle dispersions in the size ranges of concern (2.5-3.5 µm and 2.5-500 µm) before conducting DSD measurements. After conducting this validation analysis, the reviewer also recommended presenting the results in the report. Without such validation, the reviewer stated that the accuracy of data generated by the LISST was questionable.[AK]

4	*Does the discussion in Task A of the report about experimental results along with the results from numerical modeling using data obtained from the experiments present sufficient new data and knowledge, and are the findings useful for informing oil spill response planning for deepwater blowouts?*
Comments:	One reviewer commented that the Task A study, through the experimental results or modeling processes, presented information that was either new knowledge/data or corroborated research projects with similar tasking and/or objectives.[BA] This reviewer also commented that the Task A findings were useful for oil spill response planning for deepwater blowouts,[BA] although another reviewer commented that Task A was not realistic with respect to dispersant application in deepwater blowouts.[AK] Another reviewer explained that potential bias in droplet size measurements created challenges for using the Task A data in future efforts to validate or develop predictive models for oil spill response planning for deepwater blowouts.[TN] One reviewer recommended reviewing the description of the experimental procedures and conditions used in Task A and mentioned, as an example, that information about the water depth and currents in the tank used in the experiments was missing or not easy to find.[AK] One reviewer stated that the Task A findings presented useful information for oil spill responders. As an example, this reviewer noted Task A results that showed for subsea well blowouts in colder temperatures, there was a temperature effect concerning TPC (with a set volume, fewer particles were dispersed in colder waters). The reviewer strongly concurred with the Task A recommendation to further test or validate the operating temperature of the LISST along with the operating temperature specifications in the LISST manufacturer manual. The reviewer emphasized that for subsea dispersant monitoring, it was essential to understand cold water temperature limits.[BA]

4	*Does the discussion in Task A of the report about experimental results along with the results from numerical modeling using data obtained from the experiments present sufficient new data and knowledge, and are the findings useful for informing oil spill response planning for deepwater blowouts?*
	One reviewer commented that the results from the Task A study were obtained using only one type of nozzle. This reviewer suggested that the draft final report should discuss the risk of extrapolating these results to different nozzles and/or response planning for actual deepwater blowouts.[AK] This reviewer commented on another issue that affected extrapolating the Task A findings for informing oil spill response planning for deepwater blowouts. The reviewer stated that for each experiment, oil and dispersant were premixed and added to the pressure vessel (page 21) before simulation of the well blowout using the horizontal jet. The reviewer emphasized that in actual oil spill responses to deepwater blowouts, jet dynamic and turbulence are used to mix oil coming out from the well and dispersant injected at the well head. The reviewer acknowledged that the efficacy of mixing and dispersant effectiveness would be different in the two scenarios (simulated jet using premixed oil/dispersant and actual dispersant application during a well blowout). The reviewer recommended discussion of this difference and the limitations for extrapolation of the Task A results to oil spill response planning for deepwater blowouts.[AK] One reviewer observed an issue with measuring interfacial tension between oil and seawater in the tank, based on the data this reviewer found in Table 3 of Appendix H. The data in the column for IFT for untreated oil appeared too high, and the reviewer suggested referring to prior measurements found in the Environment Canada database (http://www.etc-cte.ec.gc.ca/databases/OilProperties), which has data on ANS and SLC oils. The reviewer emphasized that this issue and the potential bias in the droplet size measurements cause challenges for using data generated in the Task A study to validate or develop droplet size prediction models.[TN]

5	*Are the objectives and relevance of the Task B study clearly defined? If not, what are your recommendations for improving the description of the Task B study's objectives and relevance?*
Comments:	The reviewers agreed that the objectives and relevance of the Task B study were clearly defined.[BA,FM,TN] One reviewer stated simply that they were clearly defined.[TN] One reviewer stated that the descriptions of objectives and relevance were clear for the Task B study.[FM] Another reviewer commented that the relevance of Task B was well defined in terms of the 2010 Deepwater Horizon (DWH) oil spill in the Gulf of Mexico. This reviewer stated that the objectives of the Task B study coincided well with the existing references, listing the National Response Team (NRT) guide, in particular.[BA]

5	*Are the objectives and relevance of the Task B study clearly defined? If not, what are your recommendations for improving the description of the Task B study's objectives and relevance?*
	Two of the reviewers described their understanding of the objectives of the Task B study; however, their descriptions were different.[BA,FM] One of those reviewers described the objectives that were defined for Task B as the following: translating oil fluorescence research and development (R&D) into operational tools for spill response, and evaluating optimum fluorescence wavelengths for oil detection as a function of oil type and DORs to assist responders in selecting proper sensors and establishing best practices for rapid decision-making during spill response.[FM] The other reviewer that described their understanding of the Task B study objectives provided the following list of three objectives: 1) Generate a comprehensive EEMs database, building upon existing data at DFO Canada, to provide fluorescence peak information as a function of oil type, weathering state, concentration, and DORs; 2) Critically examine the database using advanced statistical methods and models to identify wavelengths best suited for oil monitoring during dispersant application and degradation; and 3) Conduct wave tank experiments to determine submersible sensors capable of providing data comparable to scanning and/or fixed wavelength laboratory fluorometers for rapid deployment during response efforts.[BA] One reviewer commented that the importance of fluorescence to operational decision-making should be emphasized throughout Task B in order to highlight its importance to responders. As an example, the reviewer suggested changing the language on page 85, which discussed how information obtained using oil detection by fluorescence during the DWH oil spill not only supported Net Environmental Benefit Analysis (NEBA) to ensure minimal impacts on threatened coastal resources and human health from the application of spill countermeasures, but in this reviewer's opinion, also supported operational decision-making. The reviewer also suggested adding emphasis on page 85 on fluorescence and its significant contribution to subsequent Natural Resource Damage Assessment (NRDA) to confirm exposure of natural resources to (treated/untreated) oil. This reviewer referenced NOAA's *Final Programmatic Damage Assessment and Restoration Plan and Final Programmatic Environmental Impact Statement* to support the importance of fluorescence to operational decision-making for responders.[BA]

6	*Were the methods used for evaluation of oil fluorescence characteristics and sensor performance in the Task B wave tank experiments adequately characterized and clearly described?*
Comments:	In general, the reviewers agreed that the methods used for evaluation of oil fluorescence characteristics and sensor performance in the Task B wave tank experiments were adequately characterized and were clearly described.[BA,FM,TN] One reviewer simply agreed that the methods were adequately characterized and clearly defined.[TN] Another reviewer commented more specifically that the sample preparation was clear and appropriate, and that the protocols for the seawater base (salinity/temperature) were properly characterized.[BA] Another reviewer stated that generally the methodology for the experiments and the preliminary numerical method for evaluating sensor performance was adequate; however, this reviewer noted that there were additional comments about some specific points that this reviewer recommended should be addressed and those comments were provided under Specific Observations (see Section 4.3).[FM] One reviewer pointed out a limitation that the final part of the report was missing the practical approach for using the final EEM-PARAFAC data as an operational tool for spill response. This reviewer emphasized that there was no clear discussion about how this information in Task B of the report can be practically used as a tool for oil spill response.[FM] One reviewer added comments about the Task B report, noting that the figures and pictures were great illustrations of the data. With respect to the different methods for laboratory and wave tank experiments, this reviewer also added that the methods to evaluate oil fluorescence and sensor performance were discussed in manner that should allow readers to discern between them.[BA]

7	*Are the Task B conclusions logical and appropriate based on the results of the wave-tank based and laboratory-based experiments using different oil types and dispersant-to-oil (DOR) ratios? Were there any critical results not discussed or addressed in Task B of the report?*
Comments:	Two reviewers had concerns about the conclusions[FM,TN] and another reviewer commented favorably on the conclusions and results.[BA] Only one reviewer commented about critical results that were not discussed or addressed in Task B of the report.[BA] One of the two reviewers with concerns about the conclusions emphasized that it was surprising that no clear conclusion was provided in the Task B study based on the results of the wave-tank based and laboratory-based experiments using different oil types and DORs.[FM] The other reviewer with concerns about the conclusions emphasized that it was important to recognize the difference between laboratory-based experiments and real-world

7	*Are the Task B conclusions logical and appropriate based on the results of the wave-tank based and laboratory-based experiments using different oil types and dispersant-to-oil (DOR) ratios? Were there any critical results not discussed or addressed in Task B of the report?*
	applicability.[TN] In contrast, another reviewer stated that the wave-tank based and laboratory-based conclusions for different oil types and DORs in Task B were decisively articulated and addressed within the report. This reviewer commented that the results connected well with the Task B objectives and the major results were all discussed and addressed.[BA] The reviewer that had stated it was surprising that no clear conclusions were provided for Task B also specifically mentioned, as an example, the results of EEM-PARAFAC analyses demonstrated that oils with different DORs resulted in different numbers of PARAFAC components and F_{max} values. This reviewer asked why no interpretation of these PARAFAC components was provided in the Task B study. The reviewer also commented that the Task B conclusions should include how the experimental results could assist responders in proper sensor selection, and help establish best practices for rapid decision-making during spill response. The reviewer also noted that other more specific comments were provided under Specific Observations (see Section 4.3).[FM] The reviewer that had stated it was important to recognize the difference between laboratory-based experiments and real-world applicability described several specific concerns. The reviewer described that in an open system, dissolved concentrations of soluble components may always remain low, whereas in a closed beaker, they can become elevated. The reviewer specifically noted the discussion in Task B of how the fluorescence intensity ratio (FIR) was reduced at higher DORs, and commented that this finding may be an artifact of the laboratory system. First, this reviewer further explained that surfactants would quickly leach from dispersed oil droplets in an open (field) system. The reviewer inferred that if surfactants were somehow responsible for reducing FIR in the laboratory, that based on this reviewer's experience, this might not actually be the case in an open (field) system. Secondly, this reviewer further explained that the same condition held true for all soluble components in oil. The reviewer emphasized that soluble aromatics may have relatively high concentrations in closed, laboratory conditions, but relatively low concentrations in open, field conditions.[TN] Only one reviewer commented about critical results that were not discussed or addressed in Task B of the report. This reviewer recommended adding brief elaboration on tip streaming, because the report mentioned observed peaks may be due to tip streaming. The reviewer suggested, as an example, adding

7	*Are the Task B conclusions logical and appropriate based on the results of the wave-tank based and laboratory-based experiments using different oil types and dispersant-to-oil (DOR) ratios? Were there any critical results not discussed or addressed in Task B of the report?*
	descriptive language such as: “Tip streaming is when small droplets “stream” off the edge of the umbrella. Tip streaming is likely the result of reduced surface tension of a droplet and the movement of surfactant molecules around the surface of a droplet because of the induced current it experiences as it rises through water at its terminal velocity.”[BA] This reviewer also inquired if there were plans to add a component module within VDROP-J, in order to include a module that could account for tip streaming.[BA]

8	*Does the discussion in Task B of the report about the evaluation of sensor performance present sufficient new data and knowledge, and are the findings useful for improving the interpretation of field fluorescence data and informing decision-making during oil spill response planning (e.g., selection of optimum sensor configuration for submersible fluorometers)?*
Comments:	All three reviewers commented, in general, that the findings from Task B were useful.[BA,FM,TN] Two reviewers commented that Task B provided new EEM data to improve interpretation of field fluorescence data, and one reviewer also added a specific observation related to new knowledge from Task B about dispersion effectiveness.[BA] One reviewer stated that the results of Task B can be useful for improving the interpretation of field fluorescence data, based on this reviewer’s expertise with such data, and for informing decision-making during oil spill response planning. This reviewer restated concerns emphasized above (see Charge Question #7) that no clear conclusions were provided for Task B in the draft final report.[FM] Another reviewer acknowledged that they were not an expert in evaluating sensor performance data, and after noting that Task B used a broad range and number of oils, this reviewer anticipated that this new data would add to the existing knowledge base.[TN] One reviewer stated that the discussion throughout Task B provided new data that supported conclusions in terms of optimum sensor configurations and the EEM table. The reviewer observed that the EEMs for the 25 oil types with varying DOR would be useful for improving the interpretation of field fluorescence data, which in turn would support informing operational

8	*Does the discussion in Task B of the report about the evaluation of sensor performance present sufficient new data and knowledge, and are the findings useful for improving the interpretation of field fluorescence data and informing decision-making during oil spill response planning (e.g., selection of optimum sensor configuration for submersible fluorometers)?*
	decision-making during oil spill response planning. This reviewer added that the Task B conclusions would also be useful for informing NEBA and NRDA decision-making.[BA] With respect to new knowledge from Task B, one reviewer stated that the agreement between the tank and Baffle Flask Test (BFT) experiments was important for connecting research initiatives, but ultimately more important as a solid indication of dispersion effectiveness (fluorescence peak position and FIR).[BA]

4. PEER REVIEWER COMMENTS BY CHARGE QUESTIONS

4.1 General Impressions

GENERAL IMPRESSIONS	
Provide overall impressions (approximately 1/2 page in length) addressing the accuracy of information presented, clarity of presentation, and soundness of conclusions.	
Lt. Brandon J. Aten	The report, "Dispersant Effectiveness, In-Situ Droplet Size Distribution and Numerical Modeling to Assess Subsurface Dispersant Injection as a Deepwater Blowout Oil Spill Response Option — and — Evaluation of Oil Fluorescence Characteristics to Improve Forensic Response Tools" satisfactorily addressed the project tasking and the associated objectives. The stated techniques and procedures within the report concerning the facility (flume) and the subsurface oil injection system were clearly articulated and implemented. Several variables associated with determining dispersant effectiveness were technically evaluated, and although other potential variables exist, I believe the accuracy of the information and the soundness of the conclusion stands firm. With certain Task (A) objectives in respect to dispersant effectiveness being measured as a shift in droplet size distribution, the findings presented in the report are useful for informing oil spill responders and planners concerning what conditions (types of dispersant, oil types, DOR, water temperature) subsea response operations could be a preferred response option during subsea blowouts. While minor suggestions or questions are included within a few of the charge questions, I believe the report stands firm in its conclusions and will serve as an excellent backbone to ongoing research within the subsea oil spill response related environment.
Dr. Ali Khelifa	The study includes extensive series of data in size distribution of oil droplets generated from submerged jet experiments in a tank under various conditions. The information presented seems to be in line with the objectives of the project. However, presentation and discussions of the data and related uncertainty need revision. Regarding the modelling component presented in Appendices G, the study is not related to the series of tank experiments presented in Draft Final report and Appendices A to E. This is a relatively simplistic study in which commercial CFD software Fluent and in-house models were used to illustrate how a jet flow can be modelled to predict the transport of positively buoy oil droplets. Comparison with observation was very limited and the presentation of the results needs revision. There is no clear link between this study and the objectives of the overall project listed in page 17 of the Draft Final Report. Regarding the modelling component presented in Appendices H, it is not clear at all what the purpose of that study that seems to be part of the modelling work conducted in Appendix G. Both modelling studies presented in Appendix G and H deal with prediction of oil droplet size distribution (DSD). While the study presented in Appendix H focus, apparently, on predicting

GENERAL IMPRESSIONS	
Provide overall impressions (approximately 1/2 page in length) addressing the accuracy of information presented, clarity of presentation, and soundness of conclusions.	
Dr. Ali Khelifa, continued	DSD far from the jet (equilibrium), the study in Appendix G includes prediction of DSD anywhere downstream from the jet. Modelling approach in Appendix G use VDROP-J model to predict the DSD, while modelling study in Appendix H preferred to use modified Weber number approach due to its simplicity compared to the Maximum Entropy Formalism approach and the approach used in VDROP-J model. This is confusing! Also, Appendix H presents experiments data for DOR of 1:250 and 1:25 not discussed or presented in the Draft Final Report. This requires clarification.
Dr. Fatemeh Mirnaghi	The main objectives of Task B of this study were defined as “developing operational tools for spill response, evaluating the optimum fluorescence wavelengths for oil detection (as a function of oil type and DOR) to assist responders selecting proper sensors and establishing Best Practices for rapid decision making during spill response”. In general, proper methodology and approach have been taken for this evaluation, and the accuracy of the presented information seems to be good. However, major revision of the report is required since the report is mainly presentation of the experimental results and numerical modeling without adequate discussion, explanation and interpretation of the results, or conclusion of the observed data. For example, the report includes the results of comparison of EEM results with GC data and EEM-PARAFAC modeling. This part of reports is representing large amount of data without sufficient discussion on the reasons for observation the results or conclusion from this observation. Also, referring back to the objectives of the Task, there is no conclusion which discusses how these results can work as a response tool to assist the responder for rapid decision making during spill response. In case of EEM-PARAFAC analysis, a substantial portion of data included in this part is pre-valuation results for model which could have not been validated. To prevent confusion, it is strongly recommended that these detailed discussions are entirely removed from the main report or transferred to the supplementary data. Some other specific comments on the materials of the Task B of the report are provided in part III of this review.

GENERAL IMPRESSIONS	
Provide overall impressions (approximately 1/2 page in length) addressing the accuracy of information presented, clarity of presentation, and soundness of conclusions.	
Dr. Tim Nedwed	The report is well written and thorough. However, there are several concerns with the experimental protocol for Task A. First, these discharges were in a shallow tank with a current. One goal was to measure the droplet size distribution of the rising plume with instruments placed down current. A challenge with this experimental set up is that buoyant droplets could rise above the measurement device before measurements could be taken. In addition, droplets will vertically partition in the plume regardless. My calculation of rise velocities indicate that crude oil droplets much greater than 100 microns could rise too fast to be detected by the first LISST that was located 5.1 m down current of the release point in a current of 1 cm/s. Unless the researchers had some method to measure these large droplets (I didn't see it described if they did), then results are all biased away from the large droplets that likely were generated when dispersants weren't used. This is a critical issue that the authors needed to address. If they didn't, then the value of the Task A study is very suspect. Second, the bimodal distribution found for the high DOR tests with the crude oils could be an artifact of the LISST instrument. The LISST has a path reduction module for use in high concentrations of particles / droplets. This is to increase the amount of laser light that penetrates to the detector. The manufacturer said this needs to be above 40%. If the authors got less than 40% light penetration, either with or without the PRM, then the bimodal distribution could be an instrument bias. Even penetration < 60% can be an issue. If this is an artifact, data obtained is biased toward small droplets that might not have existed or existed at the high concentrations observed. Third, based on the data in Table 3 of Appendix H, there appears to be an issue with measuring interfacial tension between the oil and seawater in the tank. The IFTs for untreated oil appear to high – go to prior measurements found in the Environment Canada database (http://www.etc-cte.ec.gc.ca/databases/OilProperties). It has data on ANS and SLC. All of these issues challenge the value of Task A. I did not find as significant an issue with Task B.

4.2 Responses to Charge Questions

RESPONSE TO CHARGE QUESTIONS	
Provide narrative responses to each of the eight charge questions below.	
1	*Are the objectives and relevance of the Task A study clearly defined? If not, what are your recommendations for improving the description of the Task A study's objectives and relevance?*
Lt. Brandon J. Aten	The relevant correspondence stated in connection with Task (A) was clearly articulated and defined. The correspondence illustrates the history of subsea dispersants and why reports like these are vital to oil spill response planning. Further, understanding how to evaluate subsea dispersant effectiveness and what influences these operations is fundamental to the pre-planning and operational risk assessment process. For additional reference, the International Oil Spill Conference (IOSC) report, 'Subsea Monitoring and Analytical Results: Subsea Dispersed Oil, MC252 Deepwater Horizon Release (Johns, Beckmann) is a useful report on the history of the Deepwater Horizon subsea dispersant program. One note to clarify the objectives: On page 3, it states that the main objectives of work under Task A were to evaluate high speed subsurface releases of physically and chemically dispersed oil using a flow through wave tank / flume facility. It then followed with three components (specific objectives) of the aforementioned goal. 1) Performance evaluation of dispersants for subsurface injection into subsea blowouts; 2) Tracking, modeling, and predicting the movement and spread of the deepwater plume and oil surfacing from deepwater blowouts, and; 3) Evaluating the influence of dispersant applications in reducing the concentration of volatile organic compounds emanating from the water surface. Then, on page 17, the objectives for Task A are defined and further stressed (bolded and underlined): 1) Refine existing equipment, technologies, and methodologies for subsurface dispersant application assessment and monitoring by measuring dispersed oil concentration, fluorescence, and in-situ oil droplet size distribution; 2) Evaluate effects of water temperature and dispersant on dispersion efficacy and dispersed oil droplet size distribution of oil at high temperatures; 3) Evaluate DE as a function of oil type and DOR for deepwater blowout spill response; 4) Assess the effect of dispersant application on the VOC concentration

RESPONSE TO CHARGE QUESTIONS	
Provide narrative responses to each of the eight charge questions below.	
1	*Are the objectives and relevance of the Task A study clearly defined? If not, what are your recommendations for improving the description of the Task A study's objectives and relevance?*
Lt. Brandon J. Aten, continued	in air above the air-sea interface of the wave tank; 5) Integrate droplet size distribution into deepwater blowout transport/behavior models to enable prediction of the dispersed oil droplets under high flow velocities in deepwater blowouts. While I see the connection between each of the listed objectives above, I believe it would benefit the report to clarify between goals, objectives, and research strategies. Lastly, the comment below is not directed to necessarily be considered within the report, but as a recommendation to be added within additional materials (i.e. factsheets, expanded summaries…etc.). Within the overall findings, it may be beneficial to link each finding with a specific task (A or B) and/or objective. For example, "*Addition of either Corexit 9500 or Finasol OSR 52 chemical dispersants to Alaskan North Slope (ANS), IFO 120 and South Louisiana Crude (SLC) oils decreased the Volume Mean Diameter (VMD) and shifted the Droplet Size Distribution (DSD) to smaller droplets. In general, Corexit 9500 produced smaller droplets compared to Finasol OSR 52.*" (Task A, Objective 1)
Dr. Ali Khelifa	The information presented seems to be in line with the objectives of the project.
Dr. Tim Nedwed	Objectives are clearly defined.

RESPONSE TO CHARGE QUESTIONS	
Provide narrative responses to each of the eight charge questions below.	
2	*Were the methods used for the Task A oil dispersion experiments conducted in the flow-through wave tank (flume) facility clearly described, properly implemented, and appropriate for evaluating deepwater blowouts?*
Lt. Brandon J. Aten	The methods, overall, were clearly described, referenced, and implemented. The methodology throughout Task A was efficiently captured such as background scatter files which served as an important baseline for later data files. While difficulties exist when attempting to simulate and subsequently evaluate deepwater blowouts, due to the environment and variances (DOR, oil type) involved, I believe the research team expertly executed the methods to

RESPONSE TO CHARGE QUESTIONS	
Provide narrative responses to each of the eight charge questions below.	
2	*Were the methods used for the Task A oil dispersion experiments conducted in the flow-through wave tank (flume) facility clearly described, properly implemented, and appropriate for evaluating deepwater blowouts?*
Lt. Brandon J. Aten, continued	accurately assess their Task A objectives. While reviewing Task A, I did have a few questions related to statements made concerning the procedures. The questions are listed below and were added only to potentially bolster the narrative with respect to the methods of Task A. The questions may warrant further examination by the research team (with respect to efficiently listing the methods vs. elaborating on the questions below). It was mentioned that after each experiment, the entire subsurface injector system was cleaned by flushing with toluene, acetone and fresh water prior to next experiment. How long was flushing conduct and was it consistent? Are there any associated standards and procedures? Was instrument drift checked after each testing session? Since initial droplet formation is a function of release diameter (and several other things, it might be worth highlighting that fact either when introducing the subsea dispersant injection system or within the analysis (see Note 1a). For example, the assembly to a nozzle (2.4 mm inner diameter) required scaling as a full-scale discharge could be greater than 20-40 cm in diameter. Smaller discharge orifices limit the size of droplets (with and without dispersant). However, small discharge orifices are often utilized and required to limit the mass loading of oil into the flow tank. *Note 1a*: Mentioning how the nozzle release diameter impacts droplet sizes may be worth mentioning in the following statements (concur with the assessment and need for additional testing), "In subsurface injection jet experiments, that range of diameters is narrower, where particles > 100 μm were not observed. This suggests that the combination of chemical dispersant, elevated turbulence mixing from the jet release and higher oil temperature of 80 °C yielded smaller droplets. To discern the dominant factor controlling the difference, additional testing would need to be conducted."
Dr. Ali Khelifa	How were "*triplicate experiments*" conducted? Was the tank emptied and cleaned from oil after each run, i.e. oil injection? If not, how were the contaminations from previous test addressed? How were results from the "*triplicate experiments*" for each treatment used to assess dispersant effectiveness, i.e. the effects of dispersant on droplet size

RESPONSE TO CHARGE QUESTIONS	
Provide narrative responses to each of the eight charge questions below.	
2	*Were the methods used for the Task A oil dispersion experiments conducted in the flow-through wave tank (flume) facility clearly described, properly implemented, and appropriate for evaluating deepwater blowouts?*
Dr. Ali Khelifa, continued	distribution? Based on the information listed in Tables A1 to A8 in Appendix A, some of the triplicate experiments were run the same day with relatively the same conditions and others were run in different days under different conditions. How are such experiments considered as triplicate? Size distributions and VMD data presented in the Draft Final Report (e.g. Figures 5, 6, 8, 9, 10, 12, 13, 16, …) were selected from the results of the triplicate experiments. What were the criteria used to select these distributions and VMD data to show the effect of DOR for instance? How were results from the "*triplicate experiments*" for each treatment used to quantitatively evaluate the uncertainty on dispersion efficacy? Last paragraph in page 18 of the Draft Final Report, it is mentioned that "*Water current velocities were measured at various depths and locations in the tank*". No results were presented in the report. It is recommended to add complete illustration of the vertical and horizontal profiles of the current data measured at different locations of the tank. Information about what was "*horizontal water current velocities that were consistent at all measured depths*", page 19, should be illustrated as this key information to understand the transport of the droplet plume. Why were experiments with IFO-120 and Finasol OSR S2 at DOR 1:200, 1:100 and 1:20 not run in triplicate? The ways the experiments and data for cold/warm water are presented and discussed are misleading. They may lead to misinterpretation of the effects of temperature on the processes studied. It is recommended to have the entire classification of the experiments vis-à-vis water temperatures and related discussions of the data reviewed. a. In table A1 to A8 in Appendix A, the range of cold water temperatures was 5.4-11.4 ^{o}C and 4.9-13.2 ^{o}C for ANS/Corexit 9500 and IFO-120/Corexit 9500, respectively. b. According to the delineations above, all the experiments conducted with Gas Condensate/Corexit 9500 fall under the category of cold water and not warm water as mentioned in Table A5. c. The discussions of the data for ANS and IFO-120 presented in the second paragraph in pages 35 and 49, respectively, are not consistent with the limits mentioned above. For ANS (page 35), warm and cold

RESPONSE TO CHARGE QUESTIONS	
Provide narrative responses to each of the eight charge questions below.	
2	*Were the methods used for the Task A oil dispersion experiments conducted in the flow-through wave tank (flume) facility clearly described, properly implemented, and appropriate for evaluating deepwater blowouts?*
Dr. Ali Khelifa, continued	waters are defined by water temperatures ≥ 11 °C and ≤ 10 °C. For IFO-120 (page 49), cold water experiments were identified by those run at water temperatures ranged between 4.9-7.5 °C, which is not consistent with the classification shown in Table A2. In this table the water temperatures ranged between 4.9 and 13.2 °C instead. Though the authors discussed briefly this in the last paragraph in page 50, the problem with the classifications of the experiments was also obvious in other series as mentioned above. The oil amount used was not kept constant (or close) in the experiments. Appendix C shows that this amount varied from 132 g to 380 g! This is significant and may have caused significant effects on the results. It is important that the authors discuss this variation in details and its contribution to the variations observed in the results (size distribution, VMD and TPC). As described in page 30, the flow system in tank was kept running during 12 minutes period of the measurements, but switched from recirculation mode to flow through mode. Appendix H indicates that the flow in the tank was 600 gpm. At this flow rate, water depth would have reduced by 1.4 m during the 12 minutes period to take measurements! There is a need to check consistency between the information reported in the report and the appendixes. There is also to explain and show how the flow through affected the water depth in the tank and the experiments overall.
Dr. Tim Nedwed	Unless there is additional detail about the methods (i.e., how observations of fast-rising large oil droplets were made) I don't believe they were adequate for evaluating deepwater blowouts. Also, the bimodal distribution found for the high DOR tests with the crude oils could be an artifact of the LISST instrument. The LISST has a path reduction module for use in high concentrations of particles / droplets. This is to increase the amount of laser light that penetrates to the detector. The manufacturer said this needs to be above 40%. If the authors got less than 40% light penetration, either with or without the PRM, then the bimodal distribution could be an instrument bias. Even penetration < 60% can be an issue.

RESPONSE TO CHARGE QUESTIONS	
Provide narrative responses to each of the eight charge questions below.	
3	*Were the results of the sampling as well as the dispersant effectiveness and droplet size distribution analyses in Task A adequately characterized and clearly described? Are the conclusions drawn from the dispersant effectiveness and droplet size distribution analyses logical and appropriate based on the results? Are there any additional conclusions that could be drawn?*
Lt. Brandon J. Aten	Overall, the conclusions drawn concerning the DE and DSD are sound as the QC steps were clearly defined for the LISST and in-situ fluorometers in terms outliers and preventative measures. ANS Dispersion Effectiveness: Highlighting the DSD irrespective of water temperature or added dispersant is an important element for responders to comprehend. The results are strongly formed and with the supporting figures, I do not have any additional conclusions to add. Side note, was the differentiation between warm (> 11°C) or cold (< 10°C) water temperature based on other references or a planned? (Could be used for future experiments, creating a baseline). IFO-120 Dispersion Effectiveness: The VMD values being smaller for specific treatments (DOR 1:20), validates DE as the displayed shift in DSD indicated. While the shift was to a lesser extent than ANS, that can be attributed to the viscosity of IFO-120. Similarly to ANS, I believe the conclusions are displayed efficiently. The only suggestions of additional conclusions were noted on page 59, "This suggests that the combination of chemical dispersant, elevated turbulence mixing from the jet release and higher oil temperature of 80°C yielded smaller droplets." I believe responders would be interested to observe what factors yielded smaller droplets. VOC Air Monitoring: To clarify, a majority of the instrument error was based strictly on the downstream VOC monitor? If that is the case, I believe it is important to illustrate that the VOC monitor at the jet release point was unaffected. While all VOC monitor locations are important in terms of the oil spill response, the jet release point is of particular importance due to the immediate location of platform operations.
Dr. Ali Khelifa	Sampling of droplet size distribution (LISST) was not performed after homogeneity is reached in the tank, 45 minutes after each oil addition as explained in page 31 of the Draft Final Report)? The volume mean diameter (VMD) has several names/formulations, including the D[4,3] and D[3,0]. It is recommended to show how the VMD was calculated in this study.

RESPONSE TO CHARGE QUESTIONS	
Provide narrative responses to each of the eight charge questions below.	
3	*Were the results of the sampling as well as the dispersant effectiveness and droplet size distribution analyses in Task A adequately characterized and clearly described? Are the conclusions drawn from the dispersant effectiveness and droplet size distribution analyses logical and appropriate based on the results? Are there any additional conclusions that could be drawn?*
Dr. Ali Khelifa, continued	Fifth line in the first paragraph in page 32 of the Draft Final Report: the approach used to identify and remove outliners from the LISST data consisted of removing "…*any reading that is greater than the moving mean of the dataset* ***multiplied*** *by four times the standard deviation* …". This approach is questionable and should be supported by peer-reviewed references. Apparently the authors used the "**Rule of the Huge Error**" to detect and eliminate outliners from the LISST data. If such, the statement should read: "…the dataset **plus** four times the standard deviation …". Water samples were taken from the same location as the LISST sampling locations. TPH analysis was performed on these water samples. While some work was done to compare (calibrate) data from the different fluorometers and the TPH data extracted from the water samples (pages 66-69), comparison between the results from LISST and the water samples analysis is lacking, considering the fact that bridging exit between the TPC measured by LISST and TPH measured from the water samples. In other words, why TPH analysis was not used to attempt to validate TPC data measured by the LISST? The following statement in page 66 of the Draft Final Report "… *oil concentrations within the bottles represent an average over a 30 second time period that cannot be aligned with the time series data which is generated on the time scale of seconds.*" is confusing. It is possible, via integration, to compare oil concentration from the water samples (bottle) and the time series from LISST and fluorometers. One of the major concerns the data presented in this study relates to the LISST data for size particle of 2.5 - 3 µm. As stated in the second paragraph in page 26 of the Draft Final Report, the instrument measures particle sizes in the range of 2.5 – 500 µm. This means that the data (picks) shown in many size distributions at 2.5 and 3 microns, especially at DOR of 1:20 (for instance, Figures C4 and C8), have large uncertainties and may make the calculations of the VMD bias. This limitation was not discussed in the report. It is highly recommended to have the authors discuss in details the limitations of the LISST to measure droplet size in lower range 2.5 – 3.5 µm and how that limitation affects the uncertainty of the size distributions and related VMDs obtained in this study. For instance, have the two LISST instruments been validated using certified micro particle dispersions in the size ranges of concerns (2.5 – 3.5 µm and 2.5 – 500 µm) before measurements of oil droplet

RESPONSE TO CHARGE QUESTIONS	
Provide narrative responses to each of the eight charge questions below.	
3	*Were the results of the sampling as well as the dispersant effectiveness and droplet size distribution analyses in Task A adequately characterized and clearly described? Are the conclusions drawn from the dispersant effectiveness and droplet size distribution analyses logical and appropriate based on the results? Are there any additional conclusions that could be drawn?*
Dr. Ali Khelifa, continued	size distributions were conducted? If yes, it is recommended to show the results of this validation analysis in this report. If not, the accuracy of data generated by the LISST is questionable. Assessing dispersant effectiveness based on measurements of oil droplet size distribution in one location in the tank in most of the experiments is not sufficient. An important aspect of the assessment of dispersant effectiveness relates to the ability to minimize coalescence of small droplet initially formed. For this, it is highly recommended to show in Appendix C how oil droplet size distributions measured with downstream LISST and present them side-by-side with those measured with Jet Release LISST (presented in Appendix C). It surprising that the authors presented all the data obtained with Jet Release LISST in Appendix C and only few from the Downstream LISST (Figures 13, 20). The effects of water temperature on the dispensability of ANS/Corexit 9500 were discussed in page 37 and figures 14 and 15. It is recommended to also discuss these effects on the dispensability of IFO 120/Corexit 9500 for 1:20 DOR.
Dr. Tim Nedwed	Droplet size distribution may not have been adequately characterized as described above and below.

RESPONSE TO CHARGE QUESTIONS	
Provide narrative responses to each of the eight charge questions below.	
4	*Does the discussion in Task A of the report about experimental results along with the results from numerical modeling using data obtained from the experiments present sufficient new data and knowledge, and are the findings useful for informing oil spill response planning for deepwater blowouts?*
Lt. Brandon J. Aten	The information throughout Task A, whether through the experimental results or modeling processes, either presented new knowledge/data or corroborated research projects with similar tasking and/or objectives. The findings presented useful information to responders such as during subsea well blowouts in colder temperatures, there is a temperature effect concerning TPC (with a set volume, fewer particles dispersed in colder waters).

RESPONSE TO CHARGE QUESTIONS	
Provide narrative responses to each of the eight charge questions below.	
4	*Does the discussion in Task A of the report about experimental results along with the results from numerical modeling using data obtained from the experiments present sufficient new data and knowledge, and are the findings useful for informing oil spill response planning for deepwater blowouts?*
Lt. Brandon J. Aten, continued	Strongly concur with report's recommendation to further test or validate (IAW manufacture manual) the operating temperature of the LISST. It is essential, for purposes related to subsea dispersant monitoring, that cold water temperature limits are understood.
Dr. Ali Khelifa	Results from this study were obtained using one type of nozzle. The risk to extrapolate these results to different nozzles and/or real subsea well blowouts needs to be discussed. Oil and dispersant were premixed and added to pressure vessel (page 21) before the simulation of the well blow out using horizontal jet. This is far from being the case in real applications of dispersant to oil well blowout. In real application, jet dynamic and turbulence are used to mix oil coming out from the well and dispersant injected at the well head. Certainly, the efficacy of mixing and dispersant effectiveness would be different in two scenarios (simulated jet using premixed oil/dispersant and real application of dispersant application during well blowout). It is recommended to discuss this difference and the limitations to extrapolate the results of this study to real world. For clarity, it is recommended reviewing the description of the experimental procedure and conditions used. For instance, information of the water depth used in the experiments and currents in the tank are missing, or not easy to find.
Dr. Tim Nedwed	Based on the data in Table 3 of Appendix H, there appears to be an issue with measuring interfacial tension between the oil and seawater in the tank. The IFTs for untreated oil appear too high – go to prior measurements found in the Environment Canada database (http://www.etc-cte.ec.gc.ca/databases/OilProperties). It has data on ANS and SLC. This issue and the potential bias in the drop-size measurements cause challenges for using the data generated in this study to validate / develop droplet-size prediction models.

<table>
<tr><th colspan="2">RESPONSE TO CHARGE QUESTIONS</th></tr>
<tr><td colspan="2">Provide narrative responses to each of the eight charge questions below.</td></tr>
<tr><td>5</td><td>Are the objectives and relevance of the Task B study clearly defined? If not, what are your recommendations for improving the description of the Task B study’s objectives and relevance?</td></tr>
<tr><td>Lt. Brandon J. Aten</td><td>The relevance of Task B was well defined in terms of DWH and the objectives coincide well with the existing references (NRT guide…etc.). I understood the objectives as the following:

1) Generate a comprehensive EEMs database, building upon existing data at the Department of Fisheries and Oceans Canada, to provide fluorescence peak information as a function of oil type, weathering state, concentration and Dispersant-to-Oil Ratios (DORs).
2) Critically examine the database using advanced statistical methods and models to identify wavelengths best suited for oil monitoring during dispersant application and degradation.
3) Conduct wave tank experiments to determine submersible sensors capable of providing data comparable to scanning and/or fixed wavelength laboratory fluorometers for rapid deployment during response efforts.

One note concerning the background of the Task B. While briefly stated, the importance of fluorescence to operational decision making should be bolstered to highlight the importance to responders. I bolder suggested language on page 85 as a potential example- “That during the 2010 Gulf of Mexico Deepwater Horizon (DWH) oil spill, oil detection by fluorescence enabled responders to discern trajectory of plumes and assess effectiveness of dispersant countermeasures (ACT, 2008; Joint Analysis Group Report, 2010). The information supported operational decision making and Net Environmental Benefit Analyses (NEBA) to ensure minimal impacts on threatened coastal resources and human health from the application of spill Countermeasures. The fluorescence also contributed significantly to subsequent Natural Resource Damage Assessments (NRDA) to confirm exposure of natural resources to (treated/untreated) oil.”

-NOAA, “Final Programmatic Damage Assessment and Restoration Plan and Final Programmatic Environmental Impact Statement”</td></tr>
<tr><td>Dr. Fatemeh Mirnaghi</td><td>The description of objectives and relevance are clear. The objectives of the Task B have been defined as translating oil fluorescence R&D into operational tools for spill response, evaluating the optimum fluorescence wavelengths for oil detection as a function of oil type and DOR to assist responders selecting proper sensors and establishing Best Practices for rapid decision making during spill response.</td></tr>
</table>

RESPONSE TO CHARGE QUESTIONS	
Provide narrative responses to each of the eight charge questions below.	
5	*Are the objectives and relevance of the Task B study clearly defined? If not, what are your recommendations for improving the description of the Task B study's objectives and relevance?*
Dr. Tim Nedwed	They were clearly defined.

RESPONSE TO CHARGE QUESTIONS	
Provide narrative responses to each of the eight charge questions below.	
6	*Were the methods used for evaluation of oil fluorescence characteristics and sensor performance in the Task B wave tank experiments adequately characterized and clearly described?*
Lt. Brandon J. Aten	Sample preparation was clear and appropriate and the protocols for the seawater base (salinity/temperature) were properly characterized. The figures/pictures were great illustrations. Between the laboratory and wave tank experiments, the methods to evaluate oil fluorescence and sensor performance were described in a way where readers should be able to delineate between the two.
Dr. Fatemeh Mirnaghi	In general, the methodology for experimental part and preliminary numerical method of evaluation for sensor performance is fine. There are just some specific points that need to be addressed which is discussed in part III of this review. In addition, the final part of the report is missing the practical approach for utilization of the final EEM-PARAFAC data as an operational tool for spill response. It is not clearly discussed that how this reported information can be practically used as a tool for oil response treatment.
Dr. Tim Nedwed	Yes

RESPONSE TO CHARGE QUESTIONS	
Provide narrative responses to each of the eight charge questions below.	
7	*Are the Task B conclusions logical and appropriate based on the results of the wave-tank based and laboratory-based experiments using different oil types and dispersant-to-oil (DOR) ratios? Were there any critical results not discussed or addressed in Task B of the report?*
Lt. Brandon J. Aten	Wave and laboratory-based conclusions for Task B, for different oil types and DOR, were decisively articulated and addressed within the report. The results connected well with the objectives initially set in Task B and the major results

RESPONSE TO CHARGE QUESTIONS	
Provide narrative responses to each of the eight charge questions below.	
7	*Are the Task B conclusions logical and appropriate based on the results of the wave-tank based and laboratory-based experiments using different oil types and dispersant-to-oil (DOR) ratios? Were there any critical results not discussed or addressed in Task B of the report?*
Lt. Brandon J. Aten, continued	were all discussed/addressed. Relating to the charge question #7, are there plans to add a component module within VDROP-J which can account for tip streaming? Also, after mentioning that the observed peak may be due to tip streaming, it may be beneficial to elaborate on tip streaming (briefly). For example, "tip streaming is when small droplets "stream" off the edge of the umbrella. Tip streaming is likely the result of reduced surface tension of a droplet and the movement of surfactant molecules around the surface of a droplet because of the induced current it experiences as it rises through the water at its terminal velocity."
Dr. Fatemeh Mirnaghi	Surprisingly, no clear conclusion has been made out of the results of Task B. For example, the results of EEM-PARAFAC analyses show that oils with different dispersant to oil ratio have resulted in different number of PARAFAC components and Fmaxs. So what are the interpretation of these PARAFAC components and how these results can assist responders to select proper sensors and establish Best Practices for rapid decision making during spill response? Some other specific comments are provided in part III of this review.
Dr. Tim Nedwed	A concern is the difference between lab-based experiments and the real world. In an open system, dissolved concentrations of soluble components may always remain low whereas in a closed beaker they can become elevated. There is a discussion of how the FIR is reduced at higher DORs. This might be an artifact of the lab system as surfactants will quickly leach from dispersed oil droplets in an open system. So if the surfactants are somehow responsible for reducing FIR in the lab, this might not be the case in an open system. The same is true for all the soluble components in the oil. The soluble aromatic may have relatively high concentrations in the lab but relatively low concentrations in the field.

RESPONSE TO CHARGE QUESTIONS	
Provide narrative responses to each of the eight charge questions below.	
8	*Does the discussion in Task B of the report about the evaluation of sensor performance present sufficient new data and knowledge, and are the findings useful for improving the interpretation of field fluorescence data and informing decision-making during oil spill response planning (e.g., selection of optimum sensor configuration for submersible fluorometers)?*
Lt. Brandon J. Aten	The discussion throughout Task B provides supported conclusions, in terms of optimum sensor configurations and the EEM table. Most importantly, they are useful to informing operational/NEBA decision making, and natural resource damage assessments. The EEMs for the 25 oil types (varying DOR) will be useful for improving the interpretation of field fluorescence data, which in turn informs oil spill response decision making (NRDA as well). Having the tank and BFT experiments in agreement is important not only for connecting research initiatives, but ultimately a solid indication of DE (peak position and FIR).
Dr. Fatemeh Mirnaghi	The results of Task B can be useful for improving the interpretation of field fluorescence data and informing decision-making during oil spill response planning, but as mentioned before not a clear conclusion has been made yet in the report.
Dr. Tim Nedwed	I'm not an expert on the existing data. The researchers used a broad range / number of oils so this new data must add to the existing knowledge base.

4.3 Specific Observations

SPECIFIC OBSERVATIONS			
NAME: Lt. Brandon J. Aten			
Provide specific observations or comments on the report mentioning page and paragraph (expand table if needed).			
	Page	***Paragraph***	***Comment or Question***
	8	4	For ANS, adequate dispersion (< 70 um droplet VMD) …. should be µ vice u. ----Corrected----- For ANS, adequate dispersion (< 70 µm droplet VMD)
	31	1	Reference available for the following statement: "previous testing of this system showed that hydrocarbon concentrations in the tank are homogenous after 45 minutes of recirculation."

SPECIFIC OBSERVATIONS			
NAME: Dr. Ali Khelifa			
Provide specific observations or comments on the report mentioning page and paragraph (expand table if needed).			
	Page	***Paragraph***	***Comment or Question***
	multiple		Figures 7, 11, 26, 28 and 31 are difficult to read.
	46		Figure 13 needs correction. The plot shown for Jet Release LISST at DOR=0 is the same as the plot for DOR1:20 for Corexit. Also should add indication if the data plotted in this figure were obtained with warm or cold water conditions.
	multiple		Should add in the caption of most figures precision on the source of data: from Jet Release LISST or Downstream LISST. Examples are Figures 5,6,10,14,15 …
	multiple		Add data/plots for DOR=0 in Figures 10, 12, 17 and 19.
	35		Last paragraph in page 35, "… and X axes represent…" should read "… and Y axis represents…".
	4, 7	Appendix G	The author referred in different locations in the report (pages 4, 7) to a "*Problem Statement Section*". Such section does not exist in the report. Such section is needed in the report. Also needed is a clear description of the goals of this study and how they relate and achieve the

SPECIFIC OBSERVATIONS			
NAME: Dr. Ali Khelifa			
Provide specific observations or comments on the report mentioning page and paragraph (expand table if needed).			
Specific Observations, continued			objectives of the project listed in page 17 of the Draft Final Report.
	2	Appendix G	The conditions of the horizontal oil jet in a tank discussed in page 2 and Figure 4 of the appendix are different from those used in the tank experiments conducted in this project and presented in the Draft Final Report. How is this modelling study linked to the tank study presented in the Draft Final Report and why did this modelling study not use results from the tank experiments to show the robustness of their modelling approach?
	2	Appendix G	There is also inconsistency between the information presented in page 2 of this Appendix and the summary presented in page 81 of the Draft Final Report. For instance, the oil mass flow rate is reported to be 3.6 L/min in the Appendix and 3.8 L/min in the Draft Final Report.
	2	Appendix G	Based on conditions reported in page 2 of the Appendix, the placement of the blue point showing the experimental conditions in Figure 1 is wrong. While the revised position may still show atomization breakup conditions, it is recommended to review this figure and the plot to avoid misinterpretations.
	4, 5	Appendix G	In Figures 2 and 3, it is recommended to show results from the JETLAG (Ua=0 cm/s) further downstream up to 4 m from the jet as shown for the JETLAG (Ua=3 cm/s). It is also recommended to show the data using linear scale in the vertical axis to better illustrate the comparison between the models (at least the first meter from the jet).
	4	Appendix G	Why do the authors refer to VDROP and VDROP-J models? What‘s the difference between them?
	6	Appendix G	Second line in the last paragraph in page 6, "…Figure 5…" should read "… Figure 6 …". Same in the fifth line in the last paragraph in page 7, "… Figure 6…" should read "…Figure

SPECIFIC OBSERVATIONS			
NAME: Dr. Ali Khelifa			
Provide specific observations or comments on the report mentioning page and paragraph (expand table if needed).			
Specific Observations, continued			7…”, authors to double check.
	6-8	Appendix G	One of the major concerns in the presentation of this report relates to the data plotted in Figure 5 to 7. The authors stated in page 7 of the Appendix and in page 81 of the Draft Final Report that in the absence of dispersant, the model VDROP-J predicted oil DSD that is very close to that measured by the LISST instrument. However, with oil/dispersant mixture, the model could not capture the peak of droplet concentration observed 5 μm. The authors used a logarithmic scale in the horizontal axis in Figure 7 to illustrate the discrepancy between the modelled and measured DSD. This is misleading. Why did the authors not use logarithmic scale in Figure 5 to show that the problem of discrepancy is absent in the modelled data obtained without dispersant? Closer look to the data shown in Figure 5 (no dispersant) and in Figure 7 (with dispersant) suggests that the same problem of discrepancy is present in both figures. It is recommended to also plot the data in Figure 5 using a logarithmic scale in the horizontal axis, and then compare with the results presented in Figure 7.
	8	Appendix G	What was the type of dispersant used to generate the experimental data for DSD shown in Figure 7?
	7	Appendix G	The authors stated in page 7 of the Appendix that the prediction of the DSD with VDROP-J in the case of oil/dispersant mixture was conducted using the same parameters used in the case of no dispersant with the exception of the interfacial tension (IFT) which was reduced by 15 fold. This means that the same initial droplet size of 500 μm was used in both cases. In a liquid-liquid atomization breakup process is it realistic to assume the same initial droplet size when the IFT of the oil/dispersant mixture injected was 15 fold lower than the pure oil? If the authors think that that this is realistic, peer-reviewed references to

SPECIFIC OBSERVATIONS			
NAME: Dr. Ali Khelifa			
Provide specific observations or comments on the report mentioning page and paragraph (expand table if needed).			
Specific Observations, continued			support their statement are required. Also, it is recommended that the authors discuss and provide clear illustration how the initial droplet size, in this study specifically, affects the end results to estimate the DSD. The initial droplet size and IFT are used to tune the model to match experimental data. It is well established within the oil spill research community that these two parameters are well known to have strong controls on the DSD. It is recommended that the authors provide supporting references to justify the use of 500 µm for the initial droplet size and 0.0013 N/m for IFT for the ANS/dispersant mixture. As the reduction of IFT is highly dispersant dependant, it is important that the author clear specify which dispersant they refer to.
	6, 7	Appendix G	Once the model was tuned using the series of data shown in Figures 5 to 6, why was the modelling approach not tested using some of new series of data generated in this project and discussed in the Draft Final Report?
	NA	Appendix G	Liquid-Liquid jet flow has been studied extensively in the literature. It is highly recommended that the authors validate their modelling results, for this project especially, regarding the turbulent dissipation rate and the eddy diffusivity along the jet, especially that these parameters have strong controls on the evolution and the transport of the DSD in the jet flow.

SPECIFIC OBSERVATIONS			
NAME: Dr. Fatemeh Mirnaghi			
Provide specific observations or comments on the report mentioning page and paragraph (expand table if needed).			
	Page	***Paragraph***	***Comment or Question***
	8-10		A comprehensive discussion of the PARAFAC results is missing in the Overall Finding at the beginning of the report.

SPECIFIC OBSERVATIONS			
NAME: Dr. Fatemeh Mirnaghi			
Provide specific observations or comments on the report mentioning page and paragraph (expand table if needed).			
Specific Observations, continued	21	3	What was the main reason for heating the oil to 80° C in the pressure vessel before releasing into the water in subsurface oil injection system? Does this temperature really simulate the environmental condition? The light oils include a substantial volatile content. At such a high temperature they, are keen to be evaporated and got released from surface of water. Has the evaporation process been taken into account?
	99 and 103	1, Figure 43	The use of Fmax1-4 in Figure 43 and its description in the text (page=99) is kind of confusing. Fmax is a name usually used as the output of EEM-PARAFAC modeling and the reader would be confused seeing the similar term here. It is recommended that another name is chosen for the peak regions.
	99	1	In page 99, it is mentioned that the supplemental results of chemical analysis and complete fluorescence results are shown in supplemental Table A. It seems that the data do not match.
	99	2	It has been mentioned that the inner filter effect correction was done base of the F_{max1} (region one in peak location with highest intensity)? How has the correction been done? Was it verified that the correction is good for all the other components fluorescing in other peak regions?
	104		Format: Is the Fmax [1] in table 9 supposed to be F_{max1}, which is actually peak location in region 1?
	108, Appendix F	Figure 44, Figure F1-F25	Format: The intensity values for coloring bar in the counter plot is not shown (clear) and it is recommended to be shown.
	109	1	Is it the total 2-3 ring or 4-5 ring PAHs or only 2-3 or 4-5 rings benzene? Please list the compounds included in 2-3 and 4-5 ring category.
	109	1	So the question is whether all the 2-3 rings or all the 4-5 rings PAHs are exciting and emitting in the same region of Ex/Em?

SPECIFIC OBSERVATIONS			
NAME: Dr. Fatemeh Mirnaghi			
Provide specific observations or comments on the report mentioning page and paragraph (expand table if needed).			
Specific Observations, continued	109-111	Figure 45 and 46	It needs to be discussed why there was no correlation between 4-5 rings PAHs with any of the Fmaxes (peaks at different regions). Isn't it due to the fact that the GC response only correlates to concentration, but the fluorescence spectroscopy response takes in account both concentration and the fluorescence response factors (which are much higher for the 4-5 ring PAHs).
	112-113	Figure 47 and 48	Comparing GC with fluorescence response in EEMs for DOR 1:20, what is the reason for that? For 2-3 ring PAHs we see a logarithmic response but not linear response anymore? Can it be due to inner filter effect which has quenched the signal for fluorescence spectroscopy?
	114	1 (Line 6)	Format: Repeated word (that)
	114	1	There should be a discussion why the FIR of the BFT is smaller than wave tank (is it due to difference in final concentration or unmatched time series, or any other reason?)
	115	Figure 49	Format: The name in Figure 49 need to be corrected to MC252 (not MS252)
	116		It is recommended that the authors provide the details for method used for split half analysis. Was the split half analysis was based on 4 or 6 splits combination? The split half analysis should be repeated using different approach for confirmation of the reproducibility of the results and accuracy of model. How were the results of this evaluation in this study?
	118	Table 10	The classification of oils in different categories usually is done via specific physicochemical properties such as density, viscosity or rarely based on the results of hydrocarbon groups. What was the base of classification of the oils in two groups of Type I (light) and Type II (medium) in this study? The physiochemical properties of intermediate fuel, medium oils, heavy oils and dilbit are very different. I do not recommend grouping all as a category (Type II).

SPECIFIC OBSERVATIONS			
NAME: Dr. Fatemeh Mirnaghi			
Provide specific observations or comments on the report mentioning page and paragraph (expand table if needed).			
Specific Observations, continued	125-129 137-148	Figures 58-64	The authors have provided unnecessary details for the results of validation of models which were failing (nor validated). I recommend the description of the parts related to the failed models or description of the path which resulted in the final model is shortened and the excess figures are removed from main report (or transferred to supplementary data) to prevent confusions to the reader. It is recommended the figures 58-64 and 73-77 are removed from the main report.
	137, and 146	1	"It is generally recommended that the PARAFAC analysis is performed on dataset with 20-100 samples. Being close to or even above 100 samples generally makes modeling simpler; however, validation would be very hard for dataset smaller than 20 samples. Because at some point the number of samples becomes a limiting condition on the number of components that can be identified "(Anal. Methods, 2013, 5, 6557; Limnol. Oceanogr.: Methods 6, 2008, 572–579) Taking to the account that only 22 samples were included in the original model, splitting the sample in to two groups (Types) has already made the validation of the model challenging, as can be seen for the DOR: 1:100 and DOR 0 (137-145). Therefore, splitting these samples into subgroups does not make it any better, even worse.
	141 and 146	1 and 2	It is not clear when the models for DOR 0 and DOR 100 have already been validated. What is the reason for splitting the data to two types and re-performing the validation? It should be noted that 70% (page 141) and 68% (page 146) agreement between the spitted half are not good enough for validation of the model. I recommend that the original EEM-PARAFAC data analysis (without dividing to two groups) is used for the final evaluation. The case of DOR 1:20 was different compared

SPECIFIC OBSERVATIONS			
NAME: Dr. Fatemeh Mirnaghi			
Provide specific observations or comments on the report mentioning page and paragraph (expand table if needed).			
Specific Observations, continued			with DOR 0 and DOR 1:100, because of more significant effect of dispersant for dissolution of oil into the water column.
	150		What are the main objectives for running the PARAFAC model for selected PAHs? Why only those four PAHs were chosen for analysis out of many others? Oil is a very complex matrix, including hundreds of PAHs. However, some specific PAHs are dominant in the oil but fluorescence spectroscopy is not very selective and it is hard to find out the exact components. For example, we might see the same signal for naphthalene and its alkaline derivatives. Many papers have tried to correlate the Ex/Em profile of PARAFAC factors to that of the main PAHs in the oil. This is a semi qualitative evaluation to better understand the chemistry of the most significant component of the oil but not a precise conclusion. In this report, it is not clear that why authors have selected only 4 PAHs and then have run PARAFAC model out of that. If the counter plot of each individual PAH was required, it could have been obtained by running PAH standards individually to know what is the range for Ex and Em. Why they needed to be included in a PARAFAC model? The other question is how many samples in total were used for building the PAH PARAFAC model? No conclusion was made in this part of the report.
	154		I disagree with the conclusion that made on page 154, comparing the protein versus PAH results: The factors that have been seen for proteins especially Ex/Em 221/353, is close to the range of Fmax1(Ex/Em 224/340) for DOR=0.

SPECIFIC OBSERVATIONS			
NAME: Dr. Fatemeh Mirnaghi			
Provide specific observations or comments on the report mentioning page and paragraph (expand table if needed).			
Specific Observations, continued			I believe it should be concluded here that care should be taken for interpreting the results, since the range of Ex/Em of aromatic compounds in oil is very similar to the CDOM and proteins.

SPECIFIC OBSERVATIONS			
NAME: Dr. Tim Nedwed			
Provide specific observations or comments on the report mentioning page and paragraph (expand table if needed).			
	Page	***Paragraph***	***Comment or Question***
	4	2	Don't think there is a relevant subsea spill scenario for a heavy refined product. It won't come out of a well and it is very unlikely to be transferred by subsea pipelines.
	4	2	I didn't see actual currents used described in the main body of the report.
	4	3	What were the distances downstream and the depths for the discrete sampling?
	4	4	Note: The size range limitation of LISST does require flowing oil at a high enough rate that so there is enough turbulence to break physically dispersed oil into droplets that are within the range. This limits the flowrates that can be tested.
	7	2	Note: You have to be careful when comparing these closed system spectra to what would occur in the real world. In the baffled flask, concentrations of surfactants and association of surfactants with oil droplets will be much different than in an open system. The closed system allows concentrations of surfactants to be very high in the water phase and this will do two things -- increase the dissolved concentration of surfactants compared to what would be observed in the real world and slow the leaching of surfactants from oil droplets to the water thereby elevating the concentration of surfactants in the water. In the real world, dissolved surfactants

SPECIFIC OBSERVATIONS			
NAME: Dr. Tim Nedwed			
Provide specific observations or comments on the report mentioning page and paragraph (expand table if needed).			
Specific Observations, continued			concentrations will always be low and this will increase leaching rates of surfactants from oil droplets because the rate is directly proportional to the difference in concentration across the boundary layer between the oil droplet surface and the bulk water.
	7	3	Good to see this!
	8	2	Consider splitting overall findings by Task A & B.
	8	Item 2	Shouldn't this be 1:250? I didn't think you tested 1:200.
	8	Item 2	Are you certain the bimodal distributions you are seeing aren't an artifact of overwhelming the LISST with small droplets that don't allow enough transmittance through the test chamber?
	8	Item 2	What about DOR between 1:100?
	8	Item 2	You can't directly make this statement comparing the droplet size observations made in experiments with a 2.4 mm discharge orifice to what might occur with a full-size release that might have a 40 cm orifice. A DOR of 1:20 might produce much larger droplets for a full-scale release for similar release momentum/turbulence/velocity. The modified Weber number and VDrop J algorithms can be used to convert the observed droplet size to full-scale assuming equal non-dimensional descriptions of the release properties.
	8	Item 3	Shouldn't this be written to say "As expected, particle size analyses...." because large droplets would be moving more rapidly to the surface leaving only smaller droplets in at any depth as you move further downstream. Or are you trying to say that droplets are still breaking up as you move further from the source? I'm not sure how you would distinguish the difference using the system you studied.
	8	Item 3	Maybe because this denser oil was closer to neutrally buoyant so even larger droplets rose slowly?
	8	Item 4	I think you should be careful about describing <70 micron droplets as adequate dispersion for subsea dispersant use. This droplet size is a rule-of-thumb

SPECIFIC OBSERVATIONS			
NAME: Dr. Tim Nedwed			
Provide specific observations or comments on the report mentioning page and paragraph (expand table if needed).			
Specific Observations, continued			for surface application of dispersants because a surface wave only mixes oil a few feet into the upper water column allowing droplets larger than this to surface too quickly. Subsea (depending on the depth of the release) can have many 100's or 1000's of feet for oil droplets to rise through the water column. Thus, droplets much larger than 70 microns can stay entrained in the water column much longer allowing greater dissolution of soluble components in the oil and biodegradation. So, droplets of a couple hundred microns may stay entrained in the water column indefinitely or for very long periods.
	9	Item 5	Were the cold water tests well above the oil's pour point?
	9	Item 5	Last sentence -- as above, this depends on the water depth if talking about subsea dispersants. Further, there is no scenario I can think of where an IFO would ever spill subsea.
	9	Item 6	We used the LISST at 4 °C and didn't have a problem.
	9	Item 9 2nd sentence	This is the first I recall reading about tests with a gas condensate. One thing to point out about well blowouts is that they will always be releases of live oils. That is, oil that is saturated with gas. This means that the oil will have much lower density and viscosity than the dead oils you tested. A gas condensate may be more representative of a live oil than either ANS or SLC. Further, the gas condensate is likely a better surrogate for studying surface VOC concentrations because it would have more VOC's then either ANS or SLC. The gas condensate is also a stabilized oil (dead oil) but it would have more volatiles. Still, it would be tough to represent real world conditions with your shallow tank. In the real world, many / most of the volatiles might be dissolved in the water column before they reach the surface.
	10	Item 12	Is there more detail to put here -- e.g., predicted d50 versus observed. Is their data for SLC and IFO?

SPECIFIC OBSERVATIONS			
NAME: Dr. Tim Nedwed			
Provide specific observations or comments on the report mentioning page and paragraph (expand table if needed).			
Specific Observations, continued	14	1 last sentence	One of the most important advantages (if not the most important) was injection reduced the amount of oil surfacing near the well site to protect the health and safety of responders by limiting the amount of VOCs.
	15	2 2nd to last sentence	Natural gas is primarily methane but it also contains ethane, propane, and butane.
	15	2 last sentence	I wouldn't say that this "is required for informed decision making" because conducting these experiments is very unlikely in the near term -- at least. This type of statement could lead to decisions not to use dispersant until these very challenging studies are completed. Scale testing such as that described in this report can support informed decision making.
	16	1	Not sure I know what “hydrodynamic regime” means in this context.
	18	2	What was the salinity of the seawater?
	21	3	I think the injection method is important to know and should be included in the Executive Summary. Premixing of dispersant with oil won't be possible in a real scenario so this is an artificiality.
	26	2 3rd sentence	The downstream location of the LISST has must have biased the measurements because larger droplets might have risen above the depth of the instrument by the time the plume reached it -- this would be particularly true for the tests without dispersant. Can you model the plume to determine how much bias would be expected for "standard" size droplets expected with and without dispersant addition? That is, if you assume a particle size distribution, will the largest sizes have risen above the collection point? Understanding bias is important it these results are to be used to validate droplet size prediction models. The actual distribution could have been significantly larger than measured. My calculations of rise velocity for a 100-micron droplet indicates that ANS would rise at around 0.2

SPECIFIC OBSERVATIONS			
NAME: Dr. Tim Nedwed			
Provide specific observations or comments on the report mentioning page and paragraph (expand table if needed).			
Specific Observations, continued			cm/sec, IFO at 0.07, condensate at 0.3 cm/sec. This means that ANS would take 770 seconds to rise 1.4 m (vertical distance between nozzle and LISST—this assumes the 2m deep tank was full of water; it was likely only filled to 1.5 m and this means the vertical distance between discharge point and sensor was only 0.9m), IFO 2000 seconds, and condensate 470 seconds. If the current in the tanks was 1 cm/s and the LISST was located 5.1 m downstream of the release, then the oil plume would take 510 seconds to reach the plume. Unless I'm missing something, this means that any droplet much greater than 100 microns for the ANS/condensate (and the SLC) would rise above the LISST and not be measured. So a significant fraction of the distributions of the large droplets could have risen above the instrument before the first LISST and far more by the time the oil reached the second LISST. I don't know how this could be avoided or how this didn't bias the test results. This brings into question the value of these results – especially for the untreated oil. The authors need to explain how they accounted for oil droplets that would rise above the LISST before the plume reached it.
	27	3	Gas condensate: See discussion in Executive Summary on oil types.
	30	1 3rd sentence	This injection method should be described in the Executive Summary.
	33	1	Why the 18 hours on the roller?
	38	Figure 5	The bimodal distribution here could be an artifact. Did you use the path reduction module on the LISST? If not, you may have over concentrated the LISST and this could have caused the very small droplet artifact. It is hard for me to understand how the 2.5 micrometers bin could have such a high concentration of droplets.

SPECIFIC OBSERVATIONS			
NAME: Dr. Tim Nedwed			
Provide specific observations or comments on the report mentioning page and paragraph (expand table if needed).			
Specific Observations, continued			I'm told by LISST experts that transmission should be above 40% to avoid the optical artifacts.
	83	2	This should be d50/D. I'm not sure how you get a d50/D greater than 1 -- especially for full scale, so this can't be a way to describe distributions. Johansen used a lognormal distribution for untreated oil and a Rosin-Rammler approach for treated oil.
	Appendix G	Figure 4	The location of the LISST in this plot isn't consistent with Task A. Is the data used for the Appendix G comparisons from a different source?
	Appendix G	Figure 4	This plot shows how quickly the plume rises and even with a sensor located only 2.5 m down currents. Did the authors of Appendix G account for the differences in rise velocity for different size droplets and how this would impact modeling? That is, the plume shown in Figure 4 would not be uniform with depth as larger droplets would concentrate at the top of the plume and smaller at the bottom.
	Appendix H 32	3	This must be a mistake. IFT for ANS untreated is closer to 15 than 47 mN/m... see Environment Canada oil properties database. http://www.etc-cte.ec.gc.ca/databases/OilProperties/oil_prop_e.html. When dispersants are effectively applied IFT should drop by more than an order of magnitude at least. So, if your data are saying the IFT started out high and actually increased after dispersants were applied, there is a mistake.
	Appendix H	Table 3	There has to be a mistake in these numbers! They are too high without dispersants and they should reduce by 1 - 2 orders of magnitude with dispersant. Maybe these are measurements of the surface tension of the water in the tank?
	Appendix H 36	2	IFT and viscosity have to be important parameters in any model to estimate droplet sizes for oil in water.

SPECIFIC OBSERVATIONS			
NAME: Dr. Tim Nedwed			
Provide specific observations or comments on the report mentioning page and paragraph (expand table if needed).			
Specific Observations, continued			IFT may become less important when it is very low and then viscosity may dominate. A model that doesn't account for IFT won't be robust, however. The modified Weber model has both viscosity and IFT explicit in the equation. The A & B empirical parameters are used because of the challenge of quantifying the change in momentum of the jet after it is released from an orifice.
	Appendix H 36	3	It doesn't look to me that Reynolds scaling fits this data well. It doesn't fit the Oseberg 1:50 points well. It doesn't fit the IFO 120 untreated spring well. It doesn't fit the IFO 120 1:20 summer well or the IFO 120 1:100 summer well.
	Appendix H 37	2	The poor fit of the data to the Reynolds scaling as shown in Figure 25 / 26 and the fact that you have to change A for oil type illustrates that Reynolds scaling is not the way to go.
	Appendix H 39	2	What is d/d50?
	Appendix H 39	3	I believe Johansen proposes a Rosin-Rammler approach for untreated oil and a lognormal distribution for treated oil. Again this is d50/D (D is exit orifice diameter).
	Appendix H 65	2	The d/d50 mistake is in most / all the figures.

5. APPENDIX A: INDIVIDUAL REVIEWER COMMENTS

5.1 Lt. Brandon J. Aten

Dispersant Effectiveness, In-Situ Droplet Size Distribution and Numerical Modeling to Assess Subsurface Dispersant Injection as a Deepwater Blowout Oil Spill Response Option — and — Evaluation of Oil Fluorescence Characteristics to Improve Forensic Response Tools	
NAME: Lt. Brandon J. Aten	
AFFILIATION: U.S. Coast Guard – Office of Marine Environmental Response Policy	
DATE: July 26, 2016	
GENERAL IMPRESSIONS	
Provide overall impressions (approximately 1/2 page in length) addressing the accuracy of information presented, clarity of presentation, and soundness of conclusions.	
Comments:	The report, "Dispersant Effectiveness, In-Situ Droplet Size Distribution and Numerical Modeling to Assess Subsurface Dispersant Injection as a Deepwater Blowout Oil Spill Response Option — and — Evaluation of Oil Fluorescence Characteristics to Improve Forensic Response Tools" satisfactorily addressed the project tasking and the associated objectives. The stated techniques and procedures within the report concerning the facility (flume) and the subsurface oil injection system were clearly articulated and implemented. Several variables associated with determining dispersant effectiveness were technically evaluated, and although other potential variables exist, I believe the accuracy of the information and the soundness of the conclusion stands firm. With certain Task (A) objectives in respect to dispersant effectiveness being measured as a shift in droplet size distribution, the findings presented in the report are useful for informing oil spill responders and planners concerning what conditions (types of dispersant, oil types, DOR, water temperature) subsea response operations could be a preferred response option during subsea blowouts. While minor suggestions or questions are included within a few of the charge questions, I believe the report stands firm in its conclusions and will serve as an excellent backbone to ongoing research within the subsea oil spill response related environment.
RESPONSE TO CHARGE QUESTIONS	
Provide narrative responses to each of the eight charge questions below.	
1	*Are the objectives and relevance of the Task A study clearly defined? If not, what are your recommendations for improving the description of the Task A study's objectives and relevance?*
Comments:	The relevant correspondence stated in connection with Task (A) was clearly articulated and defined. The correspondence illustrates the history of subsea dispersants and why reports like these are vital to oil spill response planning. Further, understanding how to evaluate subsea dispersant effectiveness and what influences these operations is fundamental to the pre-planning and operational risk assessment process. For additional reference, the International Oil Spill Conference (IOSC) report, 'Subsea Monitoring and Analytical Results: Subsea Dispersed Oil, MC252 Deepwater Horizon Release (Johns, Beckmann) is a useful report on the history of the Deepwater Horizon subsea

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NAME: Lt. Brandon J. Aten	
	dispersant program. One note to clarify the objectives: On page 3, it states that the main objectives of work under Task A were to evaluate high speed subsurface releases of physically and chemically dispersed oil using a flow through wave tank / flume facility. It then followed with three components (specific objectives) of the aforementioned goal. (1) Performance evaluation of dispersants for subsurface injection into subsea blowouts; (2) Tracking, modeling, and predicting the movement and spread of the deepwater plume and oil surfacing from deepwater blowouts, and; (3) Evaluating the influence of dispersant applications in reducing the concentration of volatile organic compounds emanating from the water surface. Then, on page 17, the objectives for Task A are defined and further stressed (bolded and underlined): 1) Refine existing equipment, technologies, and methodologies for subsurface dispersant application assessment and monitoring by measuring dispersed oil concentration, fluorescence, and in-situ oil droplet size distribution; 2) Evaluate effects of water temperature and dispersant on dispersion efficacy and dispersed oil droplet size distribution of oil at high temperatures; 3) Evaluate DE as a function of oil type and DOR for deepwater blowout spill response; 4) Assess the effect of dispersant application on the VOC concentration in air above the air-sea interface of the wave tank; 5) Integrate droplet size distribution into deepwater blowout transport/behavior models to enable prediction of the dispersed oil droplets under high flow velocities in deepwater blowouts. While I see the connection between each of the listed objectives above, I believe it would benefit the report to clarify between goals, objectives, and research strategies. Lastly, the comment below is not directed to necessarily be considered within the report, but as a recommendation to be added within additional materials

Dispersant Effectiveness, In-Situ Droplet Size Distribution and Numerical Modeling to Assess Subsurface Dispersant Injection as a Deepwater Blowout Oil Spill Response Option — and — Evaluation of Oil Fluorescence Characteristics to Improve Forensic Response Tools	
NAME: Lt. Brandon J. Aten	
	(i.e. factsheets, expanded summaries…etc.). Within the overall findings, it may be beneficial to link each finding with a specific task (A or B) and/or objective. For example, "*Addition of either Corexit 9500 or Finasol OSR 52 chemical dispersants to Alaskan North Slope (ANS), IFO 120 and South Louisiana Crude (SLC) oils decreased the Volume Mean Diameter (VMD) and shifted the Droplet Size Distribution (DSD) to smaller droplets. In general, Corexit 9500 produced smaller droplets compared to Finasol OSR 52.*" (Task A, Objective 1)

2	*Were the methods used for the Task A oil dispersion experiments conducted in the flow-through wave tank (flume) facility clearly described, properly implemented, and appropriate for evaluating deepwater blowouts?*
Comments:	The methods, overall, were clearly described, referenced, and implemented. The methodology throughout Task A was efficiently captured such as background scatter files which served as an important baseline for later data files. While difficulties exist when attempting to simulate and subsequently evaluate deepwater blowouts, due to the environment and variances (DOR, oil type) involved, I believe the research team expertly executed the methods to accurately assess their Task A objectives. While reviewing Task A, I did have a few questions related to statements made concerning the procedures. The questions are listed below and were added only to potentially bolster the narrative with respect to the methods of Task A. The questions may warrant further examination by the research team (with respect to efficiently listing the methods vs. elaborating on the questions below). It was mentioned that after each experiment, the entire subsurface injector system was cleaned by flushing with toluene, acetone and fresh water prior to next experiment. How long was flushing conduct and was it consistent? Are there any associated standards and procedures? Was instrument drift checked after each testing session? Since initial droplet formation is a function of release diameter (and several other things, it might be worth highlighting that fact either when introducing the subsea dispersant injection system or within the analysis (see Note 1a). For example, the assembly to a nozzle (2.4 mm inner diameter) required

Dispersant Effectiveness, In-Situ Droplet Size Distribution and Numerical Modeling to Assess Subsurface Dispersant Injection as a Deepwater Blowout Oil Spill Response Option — and — Evaluation of Oil Fluorescence Characteristics to Improve Forensic Response Tools	
NAME: Lt. Brandon J. Aten	
	scaling as a full-scale discharge could be greater than 20-40 cm in diameter. Smaller discharge orifices limit the size of droplets (with and without dispersant). However, small discharge orifices are often utilized and required to limit the mass loading of oil into the flow tank. *Note 1a*: Mentioning how the nozzle release diameter impacts droplet sizes may be worth mentioning in the following statements (concur with the assessment and need for additional testing), "In subsurface injection jet experiments, that range of diameters is narrower, where particles > 100 µm were not observed. This suggests that the combination of chemical dispersant, elevated turbulence mixing from the jet release and higher oil temperature of 80° C yielded smaller droplets. To discern the dominant factor controlling the difference, additional testing would need to be conducted."

3	*Were the results of the sampling as well as the dispersant effectiveness and droplet size distribution analyses in Task A adequately characterized and clearly described? Are the conclusions drawn from the dispersant effectiveness and droplet size distribution analyses logical and appropriate based on the results? Are there any additional conclusions that could be drawn?*
Comments:	Overall, the conclusions drawn concerning the DE and DSD are sound as the QC steps were clearly defined for the LISST and in-situ fluorometers in terms outliers and preventative measures. ANS Dispersion Effectiveness: Highlighting the DSD irrespective of water temperature or added dispersant is an important element for responders to comprehend. The results are strongly formed and with the supporting figures, I do not have any additional conclusions to add. Side note, was the differentiation between warm (> 11° C) or cold (< 10° C) water temperature based on other references or a planned? (Could be used for future experiments, creating a baseline). IFO-120 Dispersion Effectiveness: The VMD values being smaller for specific treatments (DOR 1:20), validates DE as the displayed shift in DSD indicated. While the shift was to a lesser extent than ANS, that can be attributed to the viscosity of IFO-120. Similarly to ANS, I believe the conclusions are displayed efficiently. The only suggestions of additional conclusions were noted on page 59, "This suggests that the combination of chemical dispersant, elevated turbulence mixing from the jet release and higher oil temperature of 80° C yielded smaller droplets." I believe responders would be interested to observe what factors yielded smaller droplets.

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	VOC Air Monitoring: To clarify, a majority of the instrument error was based strictly on the downstream VOC monitor? If that is the case, I believe it is important to illustrate that the VOC monitor at the jet release point was unaffected. While all VOC monitor locations are important in terms of the oil spill response, the jet release point is of particular importance due to the immediate location of platform operations.

4	*Does the discussion in Task A of the report about experimental results along with the results from numerical modeling using data obtained from the experiments present sufficient new data and knowledge, and are the findings useful for informing oil spill response planning for deepwater blowouts?*
Comments:	The information throughout Task A, whether through the experimental results or modeling processes, either presented new knowledge/data or corroborated research projects with similar tasking and/or objectives. The findings presented useful information to responders such as during subsea well blowouts in colder temperatures, there is a temperature effect concerning TPC (with a set volume, fewer particles dispersed in colder waters). Strongly concur with report's recommendation to further test or validate (IAW manufacture manual) the operating temperature of the LISST. It is essential, for purposes related to subsea dispersant monitoring, that cold water temperature limits are understood.

5	*Are the objectives and relevance of the Task B study clearly defined? If not, what are your recommendations for improving the description of the Task B study's objectives and relevance?*
Comments:	The relevance of Task B was well defined in terms of DWH and the objectives coincide well with the existing references (NRT guide…etc.). I understood the objectives as the following: 1) Generate a comprehensive EEMs database, building upon existing data at the Department of Fisheries and Oceans Canada, to provide fluorescence peak information as a function of oil type, weathering state, concentration and Dispersant-to-Oil Ratios (DORs). 2) Critically examine the database using advanced statistical methods and models to identify wavelengths best suited for oil monitoring during dispersant application and degradation. 3) Conduct wave tank experiments to determine submersible sensors capable of providing data comparable to scanning and/or fixed wavelength laboratory fluorometers for rapid deployment during

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	response efforts. One note concerning the background of the Task B. While briefly stated, the importance of fluorescence to operational decision making should be bolstered to highlight the importance to responders. I bolder suggested language on page 85 as a potential example- "That during the 2010 Gulf of Mexico Deepwater Horizon (DWH) oil spill, oil detection by fluorescence enabled responders to discern trajectory of plumes and assess effectiveness of dispersant countermeasures (ACT, 2008; Joint Analysis Group Report, 2010). The information supported **operational decision making and** Net Environmental Benefit Analyses (NEBA) to ensure minimal impacts on threatened coastal resources and human health from the application of spill Countermeasures. **The fluorescence also contributed significantly to subsequent Natural Resource Damage Assessments (NRDA) to confirm exposure of natural resources to (treated/untreated) oil**." -NOAA, "*Final Programmatic Damage Assessment and Restoration Plan and Final Programmatic Environmental Impact Statement*"

6	*Were the methods used for evaluation of oil fluorescence characteristics and sensor performance in the Task B wave tank experiments adequately characterized and clearly described?*
Comments:	Sample preparation was clear and appropriate and the protocols for the seawater base (salinity/temperature) were properly characterized. The figures/pictures were great illustrations. Between the laboratory and wave tank experiments, the methods to evaluate oil fluorescence and sensor performance were described in a way where readers should be able to delineate between the two.

7	*Are the Task B conclusions logical and appropriate based on the results of the wave-tank based and laboratory-based experiments using different oil types and dispersant-to-oil (DOR) ratios? Were there any critical results not discussed or addressed in Task B of the report?*
Comments:	Wave and laboratory-based conclusions for Task B, for different oil types and DOR, were decisively articulated and addressed within the report. The results connected well with the objectives initially set in Task B and the major results were all discussed/addressed. Relating to the charge question #7, are there plans to add a component module within VDROP-J which can account for tip streaming?

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	Also, after mentioning that the observed peak may be due to tip streaming, it may be beneficial to elaborate on tip streaming (briefly). For example, "tip streaming is when small droplets "stream" off the edge of the umbrella. Tip streaming is likely the result of reduced surface tension of a droplet and the movement of surfactant molecules around the surface of a droplet because of the induced current it experiences as it rises through the water at its terminal velocity."

8	*Does the discussion in Task B of the report about the evaluation of sensor performance present sufficient new data and knowledge, and are the findings useful for improving the interpretation of field fluorescence data and informing decision-making during oil spill response planning (e.g., selection of optimum sensor configuration for submersible fluorometers)?*
Comments:	The discussion throughout Task B provides supported conclusions, in terms of optimum sensor configurations and the EEM table. Most importantly, they are useful to informing operational/NEBA decision making, and natural resource damage assessments. The EEMs for the 25 oil types (varying DOR) will be useful for improving the interpretation of field fluorescence data, which in turn informs oil spill response decision making (NRDA as well). Having the tank and BFT experiments in agreement is important not only for connecting research initiatives, but ultimately a solid indication of DE (peak position and FIR).

SPECIFIC OBSERVATIONS			
Provide specific observations or comments on the report mentioning page and paragraph (expand table if needed).			
	Page	***Paragraph***	***Comment or Question***
	8	4	For ANS, adequate dispersion (< 70 um droplet VMD) …. should be µ vice u. ----Corrected----- For ANS, adequate dispersion (< 70 µm droplet VMD)
	31	1	Reference available for the following statement: "previous testing of this system showed that hydrocarbon concentrations in the tank are homogenous after 45 minutes of recirculation."

5.2 Dr. Ali Khelifa

Dispersant Effectiveness, In-Situ Droplet Size Distribution and Numerical Modeling to Assess Subsurface Dispersant Injection as a Deepwater Blowout Oil Spill Response Option — and — Evaluation of Oil Fluorescence Characteristics to Improve Forensic Response Tools	
NAME: Dr. Ali Khelifa	
AFFILIATION: Environment Canada	
DATE: September 23, 2016	
GENERAL IMPRESSIONS	
Provide overall impressions (approximately 1/2 page in length) addressing the accuracy of information presented, clarity of presentation, and soundness of conclusions.	
Comments:	The study includes extensive series of data in size distribution of oil droplets generated from submerged jet experiments in a tank under various conditions. The information presented seems to be in line with the objectives of the project. However, presentation and discussions of the data and related uncertainty need revision. Regarding the modelling component presented in Appendices G, the study is not related to the series of tank experiments presented in Draft Final report and Appendices A to E. This is a relatively simplistic study in which commercial CFD software Fluent and in-house models were used to illustrate how a jet flow can be modelled to predict the transport of positively buoy oil droplets. Comparison with observation was very limited and the presentation of the results needs revision. There is no clear link between this study and the objectives of the overall project listed in page 17 of the Draft Final Report. Regarding the modelling component presented in Appendices H, it is not clear at all what the purpose of that study that seems to be part of the modelling work conducted in Appendix G. Both modelling studies presented in Appendix G and H deal with prediction of oil droplet size distribution (DSD). While the study presented in Appendix H focus, apparently, on predicting DSD far from the jet (equilibrium), the study in Appendix G includes prediction of DSD anywhere downstream from the jet. Modelling approach in Appendix G use VDROP-J model to predict the DSD, while modelling study in Appendix H preferred to use modified Weber number approach due to its simplicity compared to the Maximum Entropy Formalism approach and the approach used in VDROP-J model. This is confusing! Also, Appendix H presents experiments data for DOR of 1:250 and 1:25 not discussed or presented in the Draft Final Report. This requires clarification.
RESPONSE TO CHARGE QUESTIONS	
Provide narrative responses to each of the charge questions below.	
1	*Are the objectives and relevance of the Task A study clearly defined? If not, what are your recommendations for improving the description of the Task A study's objectives and relevance?*
Comments:	The information presented seems to be in line with the objectives of the

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	project.

2	*Were the methods used for the Task A oil dispersion experiments conducted in the flow-through wave tank (flume) facility clearly described, properly implemented, and appropriate for evaluating deepwater blowouts?*
Comments:	How were "*triplicate experiments*" conducted? Was the tank emptied and cleaned from oil after each run, i.e. oil injection? If not, how were the contaminations from previous test addressed? How were results from the "*triplicate experiments*" for each treatment used to assess dispersant effectiveness, i.e. the effects of dispersant on droplet size distribution? Based on the information listed in Tables A1 to A8 in Appendix A, some of the triplicate experiments were run the same day with relatively the same conditions and others were run in different days under different conditions. How are such experiments considered as triplicate? Size distributions and VMD data presented in the Draft Final Report (e.g. Figures 5, 6, 8, 9, 10, 12, 13, 16, …) were selected from the results of the triplicate experiments. What were the criteria used to select these distributions and VMD data to show the effect of DOR for instance? How were results from the "*triplicate experiments*" for each treatment used to quantitatively evaluate the uncertainty on dispersion efficacy? Last paragraph in page 18 of the Draft Final Report, it is mentioned that "*Water current velocities were measured at various depths and locations in the tank*". No results were presented in the report. It is recommended to add complete illustration of the vertical and horizontal profiles of the current data measured at different locations of the tank. Information about what was "*horizontal water current velocities that were consistent at all measured depths*", page 19, should be illustrated as this key information to understand the transport of the droplet plume. Why were experiments with IFO-120 and Finasol OSR S2 at DOR 1:200, 1:100 and 1:20 not run in triplicate? The ways the experiments and data for cold/warm water are presented and discussed are misleading. They may lead to misinterpretation of the effects of temperature on the processes studied. It is recommended to have the entire classification of the experiments vis-à-vis water temperatures and related discussions of the data reviewed.

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	a. In table A1 to A8 in Appendix A, the range of cold water temperatures was 5.4-11.4 ^{o}C and 4.9-13.2 ^{o}C for ANS/Corexit 9500 and IFO-120/Corexit 9500, respectively. b. According to the delineations above, all the experiments conducted with Gas Condensate/Corexit 9500 fall under the category of cold water and not warm water as mentioned in Table A5. c. The discussions of the data for ANS and IFO-120 presented in the second paragraph in pages 35 and 49, respectively, are not consistent with the limits mentioned above. For ANS (page 35), warm and cold waters are defined by water temperatures ≥ 11 ^{o}C and ≤ 10 ^{o}C. For IFO-120 (page 49), cold water experiments were identified by those run at water temperatures ranged between 4.9-7.5 ^{o}C, which is not consistent with the classification shown in Table A2. In this table the water temperatures ranged between 4.9 and 13.2 ^{o}C instead. Though the authors discussed briefly this in the last paragraph in page 50, the problem with the classifications of the experiments was also obvious in other series as mentioned above. The oil amount used was not kept constant (or close) in the experiments. Appendix C shows that this amount varied from 132 g to 380 g! This is significant and may have caused significant effects on the results. It is important that the authors discuss this variation in details and its contribution to the variations observed in the results (size distribution, VMD and TPC). As described in page 30, the flow system in tank was kept running during 12 minutes period of the measurements, but switched from recirculation mode to flow through mode. Appendix H indicates that the flow in the tank was 600 gpm. At this flow rate, water depth would have reduced by 1.4 m during the 12 minutes period to take measurements! There is a need to check consistency between the information reported in the report and the appendixes. There is also to explain and show how the flow through affected the water depth in the tank and the experiments overall.

3	*Were the results of the sampling as well as the dispersant effectiveness and droplet size distribution analyses in Task A adequately characterized and clearly described? Are the conclusions drawn from the dispersant effectiveness and droplet size distribution analyses logical and appropriate based on the results? Are there any additional conclusions that could be drawn?*
Comments:	Sampling of droplet size distribution (LISST) was not performed after

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	homogeneity is reached in the tank, 45 minutes after each oil addition as explained in page 31 of the Draft Final Report? The volume mean diameter (VMD) has several names/formulations, including the D[4,3] and D[3,0]. It is recommended to show how the VMD was calculated in this study. Fifth line in the first paragraph in page 32 of the Draft Final Report: the approach used to identify and remove outliners from the LISST data consisted of removing "*…any reading that is greater than the moving mean of the dataset* ***<u>multiplied</u>*** *<u>by four times</u> the standard deviation* …". This approach is questionable and should be supported by peer-reviewed references. Apparently the authors used the "**Rule of the Huge Error**" to detect and eliminate outliners from the LISST data. If such, the statement should read: "…the dataset **<u>plus</u>** <u>four times</u> the standard deviation …". Water samples were taken from the same location as the LISST sampling locations. TPH analysis was performed on these water samples. While some work was done to compare (calibrate) data from the different fluorometers and the TPH data extracted from the water samples (pages 66-69), comparison between the results from LISST and the water samples analysis is lacking, considering the fact that bridging exit between the TPC measured by LISST and TPH measured from the water samples. In other words, why TPH analysis was not used to attempt to validate TPC data measured by the LISST? The following statement in page 66 of the Draft Final Report *"… oil concentrations within the bottles represent an average over a 30 second time period that cannot be aligned with the time series data which is generated on the time scale of seconds.*" is confusing. It is possible, via integration, to compare oil concentration from the water samples (bottle) and the time series from LISST and fluorometers. One of the major concerns the data presented in this study relates to the LISST data for size particle of 2.5 - 3 µm. As stated in the second paragraph in page 26 of the Draft Final Report, the instrument measures particle sizes in the range of 2.5 – 500 µm. This means that the data (picks) shown in many size distributions at 2.5 and 3 microns, especially at DOR of 1:20 (for instance, Figures C4 and C8), have large uncertainties and may make the calculations of the VMD bias. This limitation was not discussed in the report. It is highly recommended to have the authors discuss in details the limitations of the LISST to measure droplet size in lower range 2.5 – 3.5 µm and how that limitation affects the uncertainty of the size distributions and related

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	VMDs obtained in this study. For instance, have the two LISST instruments been validated using certified micro particle dispersions in the size ranges of concerns (2.5 – 3.5 µm and 2.5 – 500 µm) before measurements of oil droplet size distributions were conducted? If yes, it is recommended to show the results of this validation analysis in this report. If not, the accuracy of data generated by the LISST is questionable. Assessing dispersant effectiveness based on measurements of oil droplet size distribution in one location in the tank in most of the experiments is not sufficient. An important aspect of the assessment of dispersant effectiveness relates to the ability to minimize coalescence of small droplet initially formed. For this, it is highly recommended to show in Appendix C how oil droplet size distributions measured with downstream LISST and present them side-by-side with those measured with Jet Release LISST (presented in Appendix C). It surprising that the authors presented all the data obtained with Jet Release LISST in Appendix C and only few from the Downstream LISST (Figures 13, 20). The effects of water temperature on the dispensability of ANS/Corexit 9500 were discussed in page 37 and figures 14 and 15. It is recommended to also discuss these effects on the dispensability of IFO 120/Corexit 9500 for 1:20 DOR.

4	*Does the discussion in Task A of the report about experimental results along with the results from numerical modeling using data obtained from the experiments present sufficient new data and knowledge, and are the findings useful for informing oil spill response planning for deepwater blowouts?*
Comments:	Results from this study were obtained using one type of nozzle. The risk to extrapolate these results to different nozzles and/or real subsea well blowouts needs to be discussed. Oil and dispersant were premixed and added to pressure vessel (page 21) before the simulation of the well blow out using horizontal jet. This is far from being the case in real applications of dispersant to oil well blowout. In real application, jet dynamic and turbulence are used to mix oil coming out from the well and dispersant injected at the well head. Certainly, the efficacy of mixing and dispersant effectiveness would be different in two scenarios (simulated jet using premixed oil/dispersant and real application of dispersant application during well blowout). It is recommended to discuss this difference and the limitations to extrapolate the results of this study to real world.

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	For clarity, it is recommended reviewing the description of the experimental procedure and conditions used. For instance, information of the water depth used in the experiments and currents in the tank are missing, or not easy to find.

SPECIFIC OBSERVATIONS			
Provide specific observations or comments on the report mentioning page and paragraph (expand table if needed).			
	Page	***Paragraph***	***Comment or Question***
	multiple		Figures 7, 11, 26, 28 and 31 are difficult to read.
	46		Figure 13 needs correction. The plot shown for Jet Release LISST at DOR=0 is the same as the plot for DOR1:20 for Corexit. Also should add indication if the data plotted in this figure were obtained with warm or cold water conditions.
	multiple		Should add in the caption of most figures precision on the source of data: from Jet Release LISST or Downstream LISST. Examples are Figures 5,6,10,14,15 .
	multiple		Add data/plots for DOR=0 in Figures 10, 12, 17 and 19.
	35		Last paragraph in page 35, "… and X axes represent…" should read "… and Y axis represents…".
	4, 7	Appendix G	The author referred in different locations in the report (pages 4, 7) to a "*Problem Statement Section*". Such section does not exist in the report. Such section is needed in the report. Also needed is a clear description of the goals of this study and how they relate and achieve the objectives of the project listed in page 17 of the Draft Final Report.
	2	Appendix G	The conditions of the horizontal oil jet in a tank discussed in page 2 and Figure 4 of the appendix are different from those used in the tank experiments conducted in this project and presented in the Draft Final Report. How is this modelling study linked to the tank study presented in the Draft Final Report and why did this modelling study not use results from the tank experiments to show the robustness of their

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Specific Observations, continued			modelling approach?
	2	Appendix G	There is also inconsistency between the information presented in page 2 of this Appendix and the summary presented in page 81 of the Draft Final Report. For instance, the oil mass flow rate is reported to be 3.6 L/min in the Appendix and 3.8 L/min in the Draft Final Report.
	2	Appendix G	Based on conditions reported in page 2 of the Appendix, the placement of the blue point showing the experimental conditions in Figure 1 is wrong. While the revised position may still show atomization breakup conditions, it is recommended to review this figure and the plot to avoid misinterpretations.
	4, 5	Appendix G	In Figures 2 and 3, it is recommended to show results from the JETLAG (Ua=0 cm/s) further downstream up to 4 m from the jet as shown for the JETLAG (Ua=3 cm/s). It is also recommended to show the data using linear scale in the vertical axis to better illustrate the comparison between the models (at least the first meter from the jet).
	4	Appendix G	Why do the authors refer to VDROP and VDROP-J models? What's the difference between them?
	6	Appendix G	Second line in the last paragraph in page 6, "…Figure 5…" should read "… Figure 6 …". Same in the fifth line in the last paragraph in page 7, "… Figure 6…" should read "…Figure 7…", authors to double check.
	6-8	Appendix G	One of the major concerns in the presentation of this report relates to the data plotted in Figure 5 to 7. The authors stated in page 7 of the Appendix and in page 81 of the Draft Final Report that in the absence of dispersant, the model VDROP-J predicted oil DSD that is very close to that measured by the LISST instrument. However, with the oil/dispersant mixture, the model could not capture the peak of droplet concentration observed 5 μm. The authors used a

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			logarithmic scale in the horizontal axis in Figure 7 to illustrate the discrepancy between the modelled and measured DSD. This is misleading. Why did the authors not use logarithmic scale in Figure 5 to show that the problem of discrepancy is absent in the modelled data obtained without dispersant? Closer look to the data shown in Figure 5 (no dispersant) and in Figure 7 (with dispersant) suggests that the same problem of discrepancy is present in both figures. It is recommended to also plot the data in Figure 5 using logarithmic scale in the horizontal axis, and then compare with the results presented in Figure 7.
Specific Observations, continued	8	Appendix G	What was the type of dispersant used to generate the experimental data for DSD shown in Figure 7?
	7	Appendix G	The authors stated in page 7 of the Appendix that the prediction of the DSD with VDROP-J in the case of oil/dispersant mixture was conducted using the same parameters used in the case of no dispersant with the exception of the interfacial tension (IFT) which was reduced by 15 fold. This means that the same initial droplet size of 500 μm was used in both cases. In a liquid-liquid atomization breakup process, is it realistic to assume the same initial droplet size when the IFT of the oil/dispersant mixture injected was 15 fold lower than the pure oil? If the authors think that that this is realistic, peer-reviewed references to support their statement are required. Also, it is recommended that the authors discuss and provide clear illustration how the initial droplet size, in this study specifically, affects the end results to estimate the DSD. The initial droplet size and IFT are used to tune the model to match experimental data. It is well established within the oil spill research community that these two parameters are well known to have strong controls on the DSD. It is recommended that the authors provide

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Specific Observations, continued			supporting references to justify the use of 500 μm for the initial droplet size and 0.0013 N/m for IFT for the ANS/dispersant mixture. As the reduction of IFT is highly dispersant dependant, it is important that the author clear specify which dispersant they refer to.
	6, 7	Appendix G	Once the model was tuned using the series of data shown in Figures 5 to 6, why was the modelling approach not tested using some of new series of data generated in this project and discussed in the Draft Final Report?
	NA	Appendix G	Liquid-Liquid jet flow has been studied extensively in the literature. It is highly recommended that the authors validate their modelling results, for this project specially, regarding the turbulent dissipation rate and the eddy diffusivity along the jet, especially that these parameters have strong controls on the evolution and the transport of the DSD in the jet flow.

5.3 Dr. Fatemeh Mirnaghi

Dispersant Effectiveness, In-Situ Droplet Size Distribution and Numerical Modeling to Assess Subsurface Dispersant Injection as a Deepwater Blowout Oil Spill Response Option — and — Evaluation of Oil Fluorescence Characteristics to Improve Forensic Response Tools	
NAME: Dr. Fatemeh Mirnaghi	
AFFILIATION: Environment and Climate Change Canada	
DATE: July 18, 2016	
GENERAL IMPRESSIONS	
Provide overall impressions (approximately 1/2 page in length) addressing the accuracy of information presented, clarity of presentation, and soundness of conclusions.	
Comments:	The main objectives of Task B of this study were defined as "developing operational tools for spill response, evaluating the optimum fluorescence wavelengths for oil detection (as a function of oil type and DOR) to assist responders selecting proper sensors and establishing Best Practices for rapid decision making during spill response". In general, proper methodology and approach have been taken for this evaluation, and the accuracy of the presented information seems to be good. However, major revision of the report is required since the report is mainly presentation of the experimental results and numerical modeling without adequate discussion, explanation and interpretation of the results, or conclusion of the observed data. For example, the report includes the results of comparison of EEM results with GC data and EEM-PARAFAC modeling. This part of reports is representing large amount of data without sufficient discussion on the reasons for observation the results or conclusion from this observation. Also, referring back to the objectives of the Task, there is no conclusion which discusses how these results can work as a response tool to assist the responder for rapid decision making during spill response. In case of EEM-PARAFAC analysis, a substantial portion of data included in this part is pre-valuation results for model which could have not been validated. To prevent confusion, it is strongly recommended that these detailed discussions are entirely removed from the main report or transferred to the supplementary data. Some other specific comments on the materials of the Task B of the report are provided in part III of this review.
RESPONSE TO CHARGE QUESTIONS	
Provide narrative responses to each of the charge questions below.	

5	*Are the objectives and relevance of the Task B study clearly defined? If not, what are your recommendations for improving the description of the Task B study's objectives and relevance?*

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NAME: Dr. Fatemeh Mirnaghi	
Comments:	The description of objectives and relevance are clear. The objectives of the Task B have been defined as translating oil fluorescence R&D into operational tools for spill response, evaluating the optimum fluorescence wavelengths for oil detection as a function of oil type and DOR to assist responders selecting proper sensors and establishing Best Practices for rapid decision making during spill response.

6	*Were the methods used for evaluation of oil fluorescence characteristics and sensor performance in the Task B wave tank experiments adequately characterized and clearly described?*
Comments:	In general, the methodology for experimental part and preliminary numerical method of evaluation for sensor performance is fine. There are just some specific points that need to be addressed which is discussed in part III of this review. In addition, the final part of the report is missing the practical approach for utilization of the final EEM-PARAFAC data as an operational tool for spill response. It is not clearly discussed that how this reported information can be practically used as a tool for oil response treatment.

7	*Are the Task B conclusions logical and appropriate based on the results of the wave-tank based and laboratory-based experiments using different oil types and dispersant-to-oil (DOR) ratios? Were there any critical results not discussed or addressed in Task B of the report?*
Comments:	Surprisingly, no clear conclusion has been made out of the results of Task B. For example, the results of EEM-PARAFAC analyses show that oils with different dispersant to oil ratio have resulted in different number of PARAFAC components and Fmaxs. So what are the interpretation of these PARAFAC components and how these results can assist responders to select proper sensors and establish Best Practices for rapid decision making during spill response? Some other specific comments are provided in part III of this review.

8	*Does the discussion in Task B of the report about the evaluation of sensor performance present sufficient new data and knowledge, and are the findings useful for improving the interpretation of field fluorescence data and informing decision-making during oil spill response planning (e.g., selection of optimum sensor configuration for submersible fluorometers)?*
Comments:	The results of Task B can be useful for improving the interpretation of field fluorescence data and informing decision-making during oil spill response

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	planning, but as mentioned before not a clear conclusion has been made yet in the report.

SPECIFIC OBSERVATIONS

Provide specific observations or comments on the report mentioning page and paragraph (expand table if needed).

	Page	***Paragraph***	***Comment or Question***
	8-10		A comprehensive discussion of the PARAFAC results is missing in the Overall Finding at the beginning of the report.
	21	3	What was the main reason for heating the oil to 80° C in the pressure vessel before releasing into the water in subsurface oil injection system? Does this temperature really simulate the environmental condition? The light oils include a substantial volatile content. At such a high temperature they are keen to be evaporated and got released from surface of water. Has the evaporation process been taken into account?
	99 and 103	1, Figure 43	The use of Fmax1-4 in Figure 43 and its description in the text (page=99) is kind of confusing. Fmax is a name usually used as the output of EEM-PARAFAC modeling and the reader would be confused seeing the similar term here. It is recommended that another name is chosen for the peak regions.
	99	1	In page 99, it is mentioned that the supplemental results of chemical analysis and complete fluorescence results are shown in supplemental Table A. It seems that the data do not match.
	99	2	It has been mentioned that the inner filter effect correction was done base of the F_{max1} (region one in peak location with highest intensity)? How the correction has been done? Was it verified that the correction is good for all the other components fluorescing in other peak regions?
	104		Format: Is the Fmax ^{1} in table 9 supposed to be F_{max1}, which is actually peak location in region 1?
	108, Appendix	Figure 44, Figure F1-F25	Format: The intensity values for coloring bar in the counter plot is not shown (clear) and it is

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Specific Observations, continued	F		recommended to be shown.
	109	1	Is it the total 2-3 ring or 4-5 ring PAHs or only 2-3 or 4-5 rings benzene? Please list the compounds included in 2-3 and 4-5 ring category.
	109	1	So the question is whether all the 2-3 rings or all the 4-5 rings PAHs are exciting and emitting in the same region of Ex/Em?
	109-111	Figure 45 and 46	It needs to be discussed why there was no correlation between 4-5 rings PAHs with any of the Fmaxes (peaks at different regions). Isn't it due to the fact that the GC response only correlates to concentration, but the fluorescence spectroscopy response takes in account both concentration and the fluorescence response factors (which are much higher for the 4-5 ring PAHs).
	112-113	Figure 47 and 48	Comparing GC with fluorescence response in EEMs for DOR 1:20, what is the reason that? For 2-3 ring PAHs we see logarithmic response but not linear response anymore? Can it be due to inner filter effect which has quenched the signal for fluorescence spectroscopy?
	114	1 (Line 6)	Format: Repeated word (that)
	114	1	There should be a discussion why the FIR of the BFT is smaller than wave tank (is it due to difference in final concentration or unmatched time series, or any other reason?)
	115	Figure 49	Format: The name in Figure 49 need to be corrected to MC252 (not MS252)
	116		It is recommended that the authors provide the details for method used for split half analysis. Was the split half analysis was based on 4 or 6 splits combination? The split half analysis should be repeated using different approach for confirmation of the reproducibility of the results and accuracy of model. How were the results of this evaluation in this study?
	118	Table 10	The classification of oils in different categories usually is done via specific physicochemical properties such as density, viscosity or rarely

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Specific Observations, continued			based on the results of hydrocarbon groups. What was the base of classification of the oils in two groups of Type I (light) and Type II (medium) in this study? The physiochemical properties of intermediate fuel, medium oils, heavy oils and dilbit are very different. I do not recommend grouping all as a category (Type II).
	125-129 137-148	Figures 58-64	The authors have provided unnecessary details for the results of validation of models which were failing (nor validated). I recommend the description of the parts related to the failed models or description of the path which resulted in the final model is shortened and the excess figures are removed from main report (or transferred to supplementary data) to prevent confusions to the reader. It is recommended the figures 58-64 and 73-77 are removed from main report.
	137, and 146	1	"It is generally recommended that the PARAFAC analysis is performed on dataset with 20-100 samples. Being close to or even above 100 samples generally makes modeling simpler; however, validation would be very hard for dataset smaller than 20 samples. Because at some point the number of samples becomes a limiting condition on the number of components that can be identified "(Anal. Methods, 2013, 5, 6557; Limnol. Oceanogr.: Methods 6, 2008, 572–579) Taking to the account that only 22 samples were included in the original model, splitting the sample in to two groups (Types) has already made the validation of the model challenging, as can be seen for the DOR: 1:100 and DOR 0 (137-145). Therefore, splitting these samples into subgroups does not make it any better, even worse.
	141 and 146	1 and 2	It is not clear when the models for DOR 0 and DOR 100 have already been validated, what is the reason for splitting the data to two types and re-performing the validation. It should be noted

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Specific Observations, continued			that 70% (page 141) and 68% (page 146) agreement between the spitted half are not good enough for validation of the model. I recommend that the original EEM-PARAFAC data analysis (without dividing to two groups) is used for the final evaluation. The case of DOR 1:20 was different compared with DOR 0 and DOR 1:100, because of more significant effect of dispersant for dissolution of oil into the water column.
	150		What are the main objectives for running the PARAFAC model for selected PAHs? Why only those four PAHs were chosen for analysis out of many others? Oil is a very complex matrix, including hundreds of PAHs. However, some specific PAHs are dominant in the oil but fluorescence spectroscopy is not very selective and it is hard to find out the exact components. For example, we might see the same signal for naphthalene and its alkaline derivatives. Many papers have tried to correlate the Ex/Em profile of PARAFAC factors to that of the main PAHs in the oil. This is a semi qualitative evaluation to better understand the chemistry of the most significant component of the oil but not a precise conclusion. In this report, it is not clear that why authors have selected only 4 PAHs and then have run PARAFAC model out of that. If the counter plot of each individual PAH was required, it could have been obtained by running PAH standards individually to know what is the range for Ex and Em. Why they needed to be included in a PARAFAC model? The other question is how many samples in total were used for building the PAH PARAFAC model?

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Specific Observations, continued			No conclusion was made in this part of the report.
	154		I disagree with the conclusion that made on page 154, comparing the protein versus PAH results: The factors that have been seen for proteins especially Ex/Em 221/353, is close to the range of Fmax1(Ex/Em 224/340) for DOR=0. I believe it should be concluded here that care should be taken for interpreting the results, since the range of Ex/Em of aromatic compounds in oil is very similar to the CDOM and proteins.

5.4 Dr. Tim Nedwed

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NAME: Tim Nedwed	
AFFILIATION: ExxonMobil Upstream Research Company	
DATE: June 8, 2016	
GENERAL IMPRESSIONS	
Provide overall impressions (approximately 1/2 page in length) addressing the accuracy of information presented, clarity of presentation, and soundness of conclusions.	
Comments:	The report is well written and thorough. However, there are several concerns with the experimental protocol for Task A. First, these discharges were in a shallow tank with a current. One goal was to measure the droplet size distribution of the rising plume with instruments placed down current. A challenge with this experimental set up is that buoyant droplets could rise above the measurement device before measurements could be taken. In addition, droplets will vertically partition in the plume regardless. My calculation of rise velocities indicate that crude oil droplets much greater than 100 microns could rise too fast to be detected by the first LISST that was located 5.1 m down current of the release point in a current of 1 cm/s. Unless the researchers had some method to measure these large droplets (I didn't see it described if they did), then results are all biased away from the large droplets that likely were generated when dispersants weren't used. This is a critical issue that the authors needed to address. If they didn't, then the value of the Task A study is very suspect. Second, the bimodal distribution found for the high DOR tests with the crude oils could be an artifact of the LISST instrument. The LISST has a path reduction module for use in high concentrations of particles / droplets. This is to increase the amount of laser light that penetrates to the detector. The manufacturer said this needs to be above 40%. If the authors got less than 40% light penetration, either with or without the PRM, then the bimodal distribution could be an instrument bias. Even penetration < 60% can be an issue. If this is an artifact, data obtained is biased toward small droplets that might not have existed or existed at the high concentrations observed. Third, based on the data in Table 3 of Appendix H, there appears to be an issue with measuring interfacial tension between the oil and seawater in the tank. The IFTs for untreated oil appear too high – go to prior measurements found in the Environment Canada database (http://www.etc-cte.ec.gc.ca/databases/OilProperties). It has data on ANS and SLC. All of these issues challenge the value of Task A. I did not find as significant an issue with Task B.

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RESPONSE TO CHARGE QUESTIONS	
Provide narrative responses to each of the eight charge questions below.	
1	*Are the objectives and relevance of the Task A study clearly defined? If not, what are your recommendations for improving the description of the Task A study's objectives and relevance?*
Comments:	Objectives are clearly defined.

2	*Were the methods used for the Task A oil dispersion experiments conducted in the flow-through wave tank (flume) facility clearly described, properly implemented, and appropriate for evaluating deepwater blowouts?*
Comments:	Unless there is additional detail about the methods (i.e., how observations of fast-rising large oil droplets were made) I don't believe they were adequate for evaluating deepwater blowouts. Also, the bimodal distribution found for the high DOR tests with the crude oils could be an artifact of the LISST instrument. The LISST has a path reduction module for use in high concentrations of particles / droplets. This is to increase the amount of laser light that penetrates to the detector. The manufacturer said this needs to be above 40%. If the authors got less than 40% light penetration, either with or without the PRM, then the bimodal distribution could be an instrument bias. Even penetration < 60% can be an issue.

3	*Were the results of the sampling as well as the dispersant effectiveness and droplet size distribution analyses in Task A adequately characterized and clearly described? Are the conclusions drawn from the dispersant effectiveness and droplet size distribution analyses logical and appropriate based on the results? Are there any additional conclusions that could be drawn?*
Comments:	Droplet size distribution may not have been adequately characterized as described above and below.

4	*Does the discussion in Task A of the report about experimental results along with the results from numerical modeling using data obtained from the experiments present sufficient new data and knowledge, and are the findings useful for informing oil spill response planning for deepwater blowouts?*
Comments:	Based on the data in Table 3 of Appendix H, there appears to be an issue with measuring interfacial tension between the oil and seawater in the tank. The IFTs for untreated oil appear to high – go to prior measurements found in the Environment Canada database (http://www.etc-cte.ec.gc.ca/databases/OilProperties). It has data on ANS and SLC. This issue and the potential bias in the drop-size measurements cause challenges for using the data generated in this study to validate / develop droplet-size prediction

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	models.

5	*Are the objectives and relevance of the Task B study clearly defined? If not, what are your recommendations for improving the description of the Task B study's objectives and relevance?*
Comments:	They were clearly defined.

6	*Were the methods used for evaluation of oil fluorescence characteristics and sensor performance in the Task B wave tank experiments adequately characterized and clearly described?*
Comments:	Yes

7	*Are the Task B conclusions logical and appropriate based on the results of the wave-tank based and laboratory-based experiments using different oil types and dispersant-to-oil (DOR) ratios? Were there any critical results not discussed or addressed in Task B of the report?*
Comments:	A concern is the difference between lab-based experiments and the real world. In an open system, dissolved concentrations of soluble components may always remain low whereas in a closed beaker they can become elevated. There is a discussion of how the FIR is reduced at higher DORs. This might be an artifact of the lab system as surfactants will quickly leach from dispersed oil droplets in an open system. So if the surfactants are somehow responsible for reducing FIR in the lab, this might not be the case in an open system. The same is true for all the soluble components in the oil. The soluble aromatic may have relatively high concentrations in the lab but relatively low concentrations in the field.

8	*Does the discussion in Task B of the report about the evaluation of sensor performance present sufficient new data and knowledge, and are the findings useful for improving the interpretation of field fluorescence data and informing decision-making during oil spill response planning (e.g., selection of optimum sensor configuration for submersible fluorometers)?*
Comments:	I'm not an expert on the existing data. The researchers used a broad range / number of oils so this new data must add to the existing knowledge base.

SPECIFIC OBSERVATIONS			
Provide specific observations or comments on the report mentioning page and paragraph (expand table if needed).			
	Page	***Paragraph***	***Comment or Question***
	4	2	Don't think there is a relevant subsea spill scenario for a heavy refined product. It won't come out of a well

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Specific Observations, continued			and it is very unlikely to be transferred by subsea pipelines.
	4	2	I didn't see actual currents used described in the main body of the report.
	4	3	What were the distances downstream and the depths for the discrete sampling?
	4	4	Note: The size range limitation of LISST does require flowing oil at a high enough rate so that there is enough turbulence to break physically dispersed oil into droplets that are within the range. This limits the flowrates that can be tested.
	7	2	Note: You have to be careful when comparing these closed system spectra to what would occur in the real world. In the baffled flask, concentrations of surfactants and association of surfactants with oil droplets will be much different than in an open system. The closed system allows concentrations of surfactants to be very high in the water phase and this will do two things -- increase the dissolved concentration of surfactants compared to what would be observed in the real world and slow the leaching of surfactants from oil droplets to the water thereby elevating the concentration of surfactants in the water. In the real world, dissolved surfactants concentrations will always be low and this will increase leaching rates of surfactants from oil droplets because the rate is directly proportional to the difference in concentration across the boundary layer between the oil droplet surface and the bulk water.
	7	3	Good to see this!
	8	2	Consider splitting overall findings by Task A & B.
	8	Item 2	Shouldn't this be 1:250? I didn't think you tested 1:200.
	8	Item 2	Are you certain the bimodal distributions you are seeing aren't an artifact of overwhelming the LISST with small droplets that don't allow enough transmittance through the test chamber?
	8	Item 2	What about DOR between 1:100?
	8	Item 2	You can't directly make this statement comparing the

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Specific Observations, continued			droplet size observations made in experiments with a 2.4 mm discharge orifice to what might occur with a full-size release that might have a 40 cm orifice. A DOR of 1:20 might produce much larger droplets for a full-scale release for similar release momentum/turbulence/velocity. The modified Weber number and VDrop J algorithms can be used to convert the observed droplet size to full-scale assuming equal non-dimensional descriptions of the release properties.
	8	Item 3	Shouldn't this be written to say "As expected, particle size analyses...." because large droplets would be moving more rapidly to the surface leaving only smaller droplets in at any depth as you move further downstream. Or are you trying to say that droplets are still breaking up as you move further from the source? I'm not sure how you would distinguish the difference using the system you studied.
	8	Item 3	Maybe because this denser oil was closer to neutrally buoyant, so even larger droplets rose slowly?
	8	Item 4	I think you should be careful about describing <70 micron droplets as adequate dispersion for subsea dispersant use. This droplet size is a rule-of-thumb for surface application of dispersants because a surface wave only mixes oil a few feet into the upper water column allowing droplets larger than this to surface too quickly. Subsea (depending on the depth of the release) can have many 100's or 1000's of feet for oil droplets to rise through the water column. Thus, droplets much larger than 70 microns can stay entrained in the water column much longer allowing greater dissolution of soluble components in the oil and biodegradation. So, droplets of a couple hundred microns may stay entrained in the water column indefinitely or for very long periods.
	9	Item 5	Were the cold water tests well above the oil's pour point?
	9	Item 5	Last sentence -- as above, this depends on the water depth if talking about subsea dispersants. Further, there is no scenario I can think of where an IFO would ever spill subsea.

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Specific Observations, continued	9	Item 6	We used the LISST at 4 °C and didn't have a problem.
	9	Item 9 2nd sentence	This is the first I recall reading about tests with a gas condensate. One thing to point out about well blowouts is that they will always be releases of live oils. That is, oil that is saturated with gas. This means that the oil will have much lower density and viscosity than the dead oils you tested. A gas condensate may be more representative of a live oil than either ANS or SLC. Further, the gas condensate is likely a better surrogate for studying surface VOC concentrations because it would have more VOC's then either ANS or SLC. The gas condensate is also a stabilized oil (dead oil) but it would have more volatiles. Still it would be tough to represent real world conditions with your shallow tank. In the real world, many / most of the volatiles might be dissolved in the water column before they reach the surface.
	10	Item 12	Is there more detail to put here -- e.g., predicted d50 versus observed. Is their data for SLC and IFO.
	14	1 last sentence	One of the most important advantages (if not the most important) was injection reduced the amount of oil surfacing near the well site to protect the health and safety of responders by limiting the amount of VOCs.
	15	2 2nd to last sentence	Natural gas is primarily methane but it also contains ethane, propane, and butane.
	15	2 last sentence	I wouldn't say that this "is required for informed decision making" because conducting these experiments is very unlikely in the near term -- at least. This type of statement could lead to decisions not to use dispersant until these very challenging studies are completed. Scale testing such as that described in this report can support informed decision making.
	16	1	Not sure I know what “hydrodynamic regime” means in this context.
	18	2	What was the salinity of the seawater?
	21	3	I think the injection method is important to know and

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			should be included in the Executive Summary. Premixing of dispersant with oil won't be possible in a real scenario so this is an artificiality.
Specific Observations, continued	26	2 3rd sentence	The downstream location of the LISST must have biased the measurements because larger droplets might have risen above the depth of the instrument by the time the plume reached it -- this would be particularly true for the tests without dispersant. Can you model the plume to determine how much bias would be expected for "standard" size droplets expected with and without dispersant addition? That is, if you assume a particle size distribution, will the largest sizes have risen above the collection point. Understanding bias is important it these results are to be used to validate droplet size prediction models. The actual distribution could have been significantly larger than measured. My calculations of rise velocity for a 100 micron droplet indicates that ANS would rise at around 0.2 cm/sec, IFO at 0.07, condensate at 0.3 cm/sec. This means that ANS would take 770 seconds to rise 1.4 m (vertical distance between nozzle and LISST—this assumes the 2m deep tank was full of water…it was likely only filled to 1.5 m and this means the vertical distance between discharge point and sensor was only 0.9m), IFO 2000 seconds, and condensate 470 seconds. If the current in the tanks was 1 cm/s and the LISST was located 5.1 m downstream of the release, then the oil plume would take 510 seconds to reach the plume. Unless I'm missing something, this means that any droplet much greater than 100 microns for the ANS/condensate (and the SLC) would rise above the LISST and not be measured. So a significant fraction of the distributions of the large droplets could have risen above the instrument before the first LISST and far more by the time the oil reached the second LISST.

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Specific Observations, continued			I don't know how this could be avoided or how this didn't bias the test results. This brings into question the value of these results – especially for the untreated oil. The authors need to explain how they accounted for oil droplets that would rise above the LISST before the plume reached it.
	27	3	Gas condensate: See discussion in Executive Summary on oil types.
	30	1 3rd sentence	This injection method should be described in the Executive Summary.
	33	1	Why the 18 hours on the roller?
	38	Figure 5	The bimodal distribution here could be an artifact. Did you use the path reduction module on the LISST? If not, you may have over concentrated the LISST and this could have caused the very small droplet artifact. It is hard for me to understand how the 2.5 micrometers bin could have such a high concentration of droplets. I'm told by LISST experts that transmission should be above 40% to avoid the optical artifacts.
	83	2	This should be d50/D. I'm not sure how you get a d50/D greater than 1 -- especially for full scale, so this can't be a way to describe distributions. Johansen used a lognormal distribution for untreated oil and a Rosin-Rammler approach for treated oil.
	Appendix G	Figure 4	The location of the LISST in this plot isn't consistent with Task A. Is the data used for the Appendix G comparisons from a different source?
	Appendix G	Figure 4	This plot shows how quickly the plume rises and even with a sensor located only 2.5 m down currents. Did the authors of Appendix G account for the differences in rise velocity for different size droplets and how this would impact modeling? That is, the plume shown in Figure 4 would not be uniform with depth as larger droplets would concentrate at the top of the plume and smaller at the bottom.
	Appendix H 32	3	This must be a mistake. IFT for ANS untreated is closer to 15 than 47 mN/m... see Environment Canada

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Specific Observations, continued			oil properties database. http://www.etc-cte.ec.gc.ca/databases/OilProperties/oil_prop_e.html. When dispersants are effectively applied IFT should drop by more than an order of magnitude at least. So, if your data are saying the IFT started out high and actually increased after dispersants were applied, there is a mistake.
	Appendix H	Table 3	There has to be a mistake in these numbers! They are too high without dispersants and they should reduce by 1 - 2 orders of magnitude with dispersant. Maybe these are measurements of the surface tension of the water in the tank?
	Appendix H 36	2	IFT and viscosity have to be important parameters in any model to estimate droplet sizes for oil in water. IFT may become less important when it is very low and then viscosity may dominate. A model that doesn't account for IFT won't be robust, however. The modified Weber model has both viscosity and IFT explicit in the equation. The A & B empirical parameters are used because of the challenge of quantifying the change in momentum of the jet after it is released from an orifice.
	Appendix H 36	3	It doesn't look to me that Reynolds scaling fits this data well. It doesn't fit the Oseberg 1:50 points well. It doesn't fit the IFO 120 untreated spring well. It doesn't fit the IFO 120 1:20 summer well or the IFO 120 1:100 summer well.
	Appendix H 37	2	The poor fit of the data to the Reynolds scaling as shown in Figure 25 / 26 and the fact that you have to change A for oil type illustrates that Reynolds scaling is not the way to go.
	Appendix H 39	2	What is d/d50?
	Appendix H 39	3	I believe Johansen proposes a Rosin-Rammler approach for untreated oil and a lognormal

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Specific Observations, continued			distribution for treated oil. Again this is d50/D (D is exit orifice diameter).
	Appendix H 65	2	The d/d50 mistake is in most / all the figures.

6. APPENDIX B: PEER REVIEW MATERIALS PACKAGES

The peer review materials packages are attached separately.