
Final

**Peer Review Summary Report for the External Peer Review of
*Estimating an Oil Spill Response Gap for the U.S. Arctic Ocean***

BSEE Contract No. E14PA00008

Task Order No. E15PB00012

May 22, 2015

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1. INTRODUCTION

BSEE has requested an external peer review of the report entitled, *Estimating an Oil Spill Response Gap for the U.S. Arctic Ocean*, which was prepared by the Nuka Research and Planning Group, LLC (Nuka Research). Part of BSEE's research is committed to ensuring that functional, safe, and environmentally responsible oil spill response methods are identified and used under appropriate conditions. Understanding oil spill response limitations in the Arctic is crucial for the U.S. government and industry to develop robust spill response plans. It is important for oil spill response plan holders to know which oil spill response tactic is appropriate to the on-scene conditions, the resources available for an oil spill response, and identify resources that must be invested in. BSEE contracted Nuka Research to perform an oil spill response gap analysis for three areas in the U.S. Arctic Beaufort and Chukchi Seas. This analysis quantified the frequency that specific oil spill response tactics may not be feasible due to weather or environmental conditions. Conditions examined included wind, sea state, temperature, ice coverage, and visibility. Response options evaluated included mechanical recovery, in-situ burn, use of dispersants, and the use of air reconnaissance to track oil.

The EnDyna Team was tasked with selecting five scientific experts to evaluate the research report. The objective of this letter-style peer review is for the Department of the Interior's (DOI) Bureau of Safety and Environmental Enforcement (BSEE) to receive written comments from individual experts on the scientific merit of the research report, appropriateness of the assumptions made, and quality and relevance of the data.

In assembling these peer reviewers and coordinating the peer review, the EnDyna Team was charged with: evaluating the qualifications of peer review candidates, conducting a thorough conflict of interest (COI) screening process, independently selecting the peer reviewers, distributing review materials, maintaining contact with the peer reviewers, and developing a final peer review report. Provided below are the names and affiliations of the five experts that were selected to evaluate and provide written comments on the research report.

1.1 Identification of Experts

The experts that were selected for this peer review were identified by literature searches of scientific journals, professional societies and scientific meetings, as well as searches of our internal peer review database. As a result of these searches, the EnDyna team identified a total of 40 potential scientific experts with expertise in the following areas: (1) oil spill response in Arctic waters; (2) oil spill response tactics (including mechanical recovery, dispersant use, in-situ burning, and application from aircraft and vessels); (3) Arctic meteorological and ocean monitoring; (4) decision analysis (using multiple criteria for priority setting); and (5) international oil spill response. Of the 40 experts contacted, the EnDyna team received 13 positive responses expressing interest and availability to participate. The remaining 27 candidates were either not available during the peer review timeframe, recused themselves from the peer review due to potential conflicts, or did not respond to our invitation. Interested candidates provided their name, contact information, and curriculum vitae (CV) 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 13 interested individuals to ensure that the experts had no COI or appearance of the lack of impartiality. The screening was conducted in accordance

with BSEE Peer Review Process Manual (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 the current task.

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 the five peer reviewers and provided a list to BSEE. The names, affiliations, and expertise of the five peer reviewers are provided below.

Selected Peer Reviewers:

1.	NAME:	Silje Berger, Ph.D.
	AFFILIATION:	Norwegian Coastal Administration, Norway
	EXPERTISE:	Dr. Berger is a Senior Advisor at the Norwegian Coastal Administration's Center for Emergency Response, where she works on projects related to oil spill preparedness and response analysis, and the development of new methods and support tools for oil spill contingency. Her interests include environmental impacts, decision support tools, and the further development of governmental oil spill contingency. Dr. Berger received her diploma and doctoral degree in ecology from the University of Hannover in Germany, where she also worked as a post-doctoral researcher.
2.	NAME:	Carl Brown, Ph.D.
	AFFILIATION:	Environment Canada, Canada
	EXPERTISE:	Dr. Brown is the Manager of the Emergencies Science and Technology Section at Environment Canada. He is also the Chemical Community of Practice Leader for the Canadian Safety and Security Program. Dr. Brown's research interests include fate and effects of oils and chemicals on the environment, treatment technologies, and other countermeasures. He also specializes in airborne oil spill sensor development, and the application of laser technologies to environmental problems. Dr. Brown has a Ph.D. in Physical Chemistry from McMaster University and has authored or co-authored over 260 scientific papers and publications.
3.	NAME:	Erik Buch, Ph.D.
	AFFILIATION:	Buch Ocean, Denmark
	EXPERTISE:	Dr. Buch has more than 25 years of experience working in the areas of operational oceanography and marine climate. Prior to working as a consultant and Director of Buch Ocean, he was the Director of Centre for Ocean and Ice (2007-2013) and Head of Operational Oceanography (1998-2007) at the Danish Meteorological Institute. He has participated and led many international oceanographic research projects in the North Atlantic, North Sea, and Baltic Sea, and Arctic Ocean. Dr. Buch holds a Ph.D. in Physical Oceanography from the University of Copenhagen.
4.	NAME:	William Hutmacher, B.S.
	AFFILIATION:	Independent Consultant (formerly with U.S. Coast Guard and Alaska

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	Department of Environmental Conservation), United States
EXPERTISE:	Mr. Hutmacher works as an independent consultant in the areas of oil spill prevention, contingency planning, risk assessment, incident command system, marine operations, and oil spill response operations. Prior to working as a consultant, he served in the U.S. Coast Guard (1974-2002) performing marine safety assignments in the US and Panama, including 18 years in Alaska at marine safety offices in Anchorage, Valdez, and Juneau. He also served as Commanding Officer for the Marine Safety Office/Vessel Traffic Service Valdez and Federal On-Scene Coordinator Prince William Sound. Upon his retirement from the U.S. Coast Guard at the rank of Captain in 2002, he served as the Industry Preparedness Program Manager for Alaska Department of Environmental Conservation's Division of Spill Prevention and Response (2002-2006). Mr. Hutmacher has a B.S. in Rangeland Ecology and Sciences from the University of California Davis.

5.	NAME:	Paul Smith, M.S.
	AFFILIATION:	Ocean Smith Services, LLC, United States
	EXPERTISE:	Mr. Smith has 38 years of experience in oil spill response tactics, oil spill cleanup equipment, offshore operations planning and management. He is the Founder of OceanSmith Services, LLC, where he serves as a consultant providing oil spill response, marine operations planning, equipment design and analysis, financial modeling, and training services. Mr. Smith has a M.S. in Ocean Engineering from Massachusetts Institute of Technology and an MBA from the University of Washington.

The 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 review comments, and Section 4 provides the peer reviewer comments of each reviewer by charge question. In addition, Section 5 (Appendix A) consists of the individual peer review comments and the peer review materials package in Section 6 (Appendix B) is attached separately.

2. CHARGE QUESTIONS

The purpose of this review was to obtain written comments from individual experts on the research report entitled, *Estimating an Oil Spill Response Gap for the U.S. Arctic Ocean*. Each reviewer was charged with evaluating the report, providing their overall impressions of the scientific merit of the report, responding to nine charge questions, and providing any other specific comments on the report. The nine charge questions provided to the reviewers are included below.

1	<i>Are the objectives of the report clearly defined? If not, what are your recommendations for improving the description of objectives?</i>
2	
3	<i>Are the limitations of the approach (Section 2.5) clearly identified and described?</i>
5	
6	<i>Were there any critical results or limitations not discussed or adequately addressed in Sections 5, 6, 7, and 8 of the report?</i>
7	<i>Are the findings and overall interpretation of the results clearly discussed (Section 9)?</i>
8	<i>Are the conclusions (Section 11) logical and appropriate based on the results? Are there any additional conclusions that could be drawn?</i>
9	<i>Does this report present sufficient new data and knowledge, and are the findings useful for informing oil spill response planning?</i>

3. SUMMARY OF PEER REVIEWERS COMMENTS

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

3.1 General Impressions

The reviewers thought that the report was a sound analysis and that it contained useful information. The reviewers provided their general impressions on the accuracy and clarity of information on methodology, environmental data, response tactics, and terminology which are discussed below.

Methodology

One reviewer commented that the methodology used in this report was based on previous studies that the authors had conducted in adjacent geographic areas, but was modified and developed for this report. The reviewer suggested including the following variables: characteristics of oil, environmental weathering, and the time required to operationalize response assets and transit to the spill location in the report.¹

Another reviewer commented that the report lacked information on oil characteristics and weathering, window of opportunity, and duration of the operations for various response tactics. The reviewer also commented on the adequacy of the method for visualizing the seasonal variation and relative differences between the various response tactics. The reviewer stated that the report would be beneficial for contingency planning.²

Another reviewer concurred with the conclusion of the study regarding the feasibility of different tactics with total proportion of time. The reviewer recommended that at least 3 hours should be the minimum time required for conducting any useful response operation.³

Environmental data

One reviewer mentioned that the authors identified and explained the assumptions carefully that were made with respect to the available environmental data and the limits that were imposed due to the lack of data and data quality.¹

Another reviewer did not necessarily concur with the methods of extrapolation or the use of surrogates. The reviewer commented that the correlation of airport wind data to offshore sea conditions lacked rigor. The reviewer expressed disappointment in the absence of any discussion or consideration of the effect of ice cover and wind duration on sea state, which the reviewer believed resulted in unrealistically low wind speed limit for mechanical recovery.³

Another reviewer recommended supplementing the observations with model data, since the meteorological and oceanographic observations are sparse in the Arctic region. The reviewer discussed in detail the benefits of using model re-analysis data; however, admitted that the quality of models, and uncertainty associated with the model outputs would be a matter of concern. The reviewer highlighted that the quality of observational data would also be a concern, as it depended on the type of instruments, periodic calibration of instruments, etc., which were not discussed in the

¹ [Carl Brown](#)

² [Silje Berger](#)

³ [Paul Smith](#)

study report. This reviewer stated that at a given time, all the personnel, gear, etc., might not be readily available, which the study assumed for developing the tactics and analyzing the study results.⁴

Another reviewer stated that the report discussed and addressed the limitations in the environmental data, methods, and provided additional explanation or precautions while interpreting the results.²

Response tactics

One reviewer commented that the actual planning to choose tactics must be conducted in accordance with the current Federal and state regulations. The reviewer noted that there is a lack of reasoning on the limited number of the type of spill response tactics used in analysis, and questioned if this limitation in number was prescribed by BSEE.⁵

The reviewer commented that all possible response tactics which were not included for evaluation were clearly identified. But the extent of effectiveness of a response tactic was not estimated in the response gap analysis.¹

Terminology

One reviewer commented that the terminology in the report, such as “effective,” “ineffective,” “impossible,” “possible,” “feasible,” “not possible,” “not feasible,” “most feasible,” “impaired,” and “precluded” need to be defined, explained, or replaced.⁵

Another reviewer suggested that discussions on some obscure statements, e.g., in Section 8, on heli-torch, “most burns,” were unsubstantiated and lacked relevance to the objective of the study, and should be removed.³

Overall, the reviewers concurred that the report would be a useful tool for spill response planners to evaluate the spill response approach and facilitate the selection of spill response tactics during the summer and winter seasons in the Arctic.

3.2 Responses to Charge Questions

The section below provides the synthesis of the five peer reviewers’ comments, concerns, and suggestions to the charge questions.

1	<i>Are the objectives of the report clearly defined? If not, what are your recommendations for improving the description of objectives?</i>
Comments:	The reviewers provided varying responses to this charge question. Three of the five reviewers, in general, agreed that the objectives of the study were clearly defined. However, one reviewer noted that including short background information about the context of the study would be informative for outside readers (e.g., external researchers, international audience, etc.). The context could include the possible sources of oil spills, environmental resources at risk, and information if the study was related to the planning of specific activities.

⁴ [Erik Buch](#)

⁵ [William Hutmacher](#)

	<p>One of the reviewers who disagreed that the objectives of the study were clearly defined either in the executive summary or Section 1, suggested using the objectives statement as stated in the History & Objectives section of the Peer Review Charge Document, which was “to perform an oil spill response gap analysis for three areas in the U.S. Arctic Beaufort and Chukchi Seas,” or to include a definition of oil spill response gap analysis as BSEE might have specified.</p>
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2	<p><i>Was the methodology (Section 2) used for the responses gap analysis appropriately designed and clearly described? Were there any apparent weaknesses or gaps with the approach used to develop the environmental limits and estimate the Response Gap Index (RGI)?</i></p>
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Comments:	<p>The reviewers in general agreed that the methodology (Section 2) used for the response gap analysis was clearly described, but some reviewers had suggestions or concerns. Discussed below are the reviewers comments on response gap index, environmental limits, and terminology used in Section 2.</p> <p><u>Response Gap Index</u></p> <p>One reviewer felt that the methodology was weak due to the limited data availability on the offshore environment, the assumption in the report that the equipment and personnel would be readily available, and the lack of details on the custom program used for calculating the RGI. Several reviewers recommended providing additional references or details (published and/or peer-reviewed) on the custom program that was used for calculating RGI.¹</p> <p>Another reviewer proposed supplementing the observations with a model data and utilizing meteorological data much longer than the 5-year period being used in the report, since the data are available. The reviewer emphasized that analyzing the meteorological data for a longer duration would facilitate the understanding of changes over time, especially if climate change affected the RGI.⁴</p> <p><u>Environmental Limits</u></p> <p>One reviewer indicated that Section 2.3 was not tangible, and suggested providing a brief description on the methods and research pertaining to the limits used, rather than only referring to other publications in the report.⁴</p> <p>Another reviewer commented that the environmental limits selected were not clearly defined; especially the selection of wind limit in relation to mechanical recovery was weakly supported. The reviewer also commented that the determination of ice limits in the report was possible after reading the four references listed in Section 2.3.³</p> <p>Another reviewer acknowledged the difficulties the authors encountered in developing and verifying environmental limits for different tactics. The reviewer suggested that there are different approaches to evaluate efficiency of different tactics, including from past experiences on spills and documentation, but this</p>
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information may render itself to different interpretation. The reviewer, however, recommended that one of the best approaches to evaluate efficiency would be to review literature or documentation on past spills, and subsequently vetting the findings with the experts; even though the limitations of environment would remain a contentious topic of discussion among experts, analyst, equipment manufacturers, and responders.²

Terminology

One reviewer questioned how the scope of the analysis was determined, with respect to spill response tactics that were either included or not included (e.g. underwater dispersant injection and under ice oil removal).

In addition, the reviewer commented on the need for additional explanation and distinction between the yellow and red environmental conditions. For example, the yellow condition, “expected to impact the operations or their effectiveness,” the reviewer questioned the meaning of the impact of operations or their effectiveness, and the measurement that was used to determine the level of impact on operations or their effectiveness.

Similarly, the red condition, “precludes deployment or response ineffective,” required additional explanation. The reviewer stated that “precludes deployment” is a clear measure, while “response ineffective,” is not. The reviewer questioned if red meant 100% ineffective. The reviewer questioned the difference between yellow condition’s “impact the operations or their effectiveness” and red conditions “response ineffective.” The reviewer also commented that in all the tables showing the response limits used (Tables 12, 14, 15, 17, 18), the red heading stated, “Response: Not possible/Effective.” The reviewer suggested revising the red condition descriptions in Section 2.2.2, “Response: Precludes Deployment of Response Ineffective,” to Not Possible.

In addition, this reviewer questioned the rationale behind stating that two yellow factors would be resulting in a Response Gap Index (RGI) classification of red in Table 1 (Applying the RGI), when the yellow color meant that the operations or their effectiveness would be impacted, but not prevented.⁵

3	<i>Are the limitations of the approach (Section 2.5) clearly identified and described?</i>
Comments:	<p>Most of the reviewers referred to their suggestions on the limitations of the approach provided in the previous charge question number 2. The additional information on methodology; environmental data, response tactics, and simplified response degradation are discussed below.</p> <p><u>Methodology</u></p> <p>In general, the reviewers recommended evaluating the characteristics of oil and weathering, which was lacking in the report. The reviewers emphasized that the environmental conditions influence the efficiency of different tactics and oil</p>

weathering (e.g., evaporation, emulsification).

Environmental Data

One reviewer brought to attention the hindcasting of the environmental data to inform future conditions, which was based on the 5-year period of environmental data, rather than a longer period of data on Arctic climate, when the data are available. The reviewer commented that this approach assumed that the environmental conditions in the Arctic would not revert back to historical normal (i.e., colder) in the near future.¹

The reviewer also commented on the lack of sufficient documentation on response limits. The reviewer commented that instead of the real-world test data on oil spill response equipment performance, bench or test tank study data were utilized in the report, which would have overestimated the response tactic effectiveness. In addition, the reviewer indicated that the RGI incorporated hourly environmental data (either from direct measurements or interpolated from weekly data), rather than on sufficient duration to mobilize, deploy, and demobilize response tactics, which would lead to an overestimation of response tactic capability.¹

Another reviewer expressed his disappointment that the authors did not provide either a correlation or an explanation on onshore data with offshore conditions in Appendix A, when the reader is referred to Appendix A for an additional explanation on the same.³

Response Tactic

One reviewer commented on the assumption in the report that during favorable conditions the response tactic would be readily available, which might lead to an overestimation of response capability. The reviewer commented that the study did not estimate the extent of effectiveness of each of the response tactics (e.g., mechanical recovery rate or in-situ burn efficiency).¹

Simplified Response Degradation

One reviewer acknowledged that the report incorporated the concept of simplified response degradation. The reviewer emphasized the importance of understanding the consequence of this simplification. The reviewer also commented that the transition from effective to not effective approach was not clearly determined in the report. The reviewer suggested that the stakeholders often want a simple answer of yes/no, which lacks to reveal the complexity of environmental conditions for different tactics.²

Another reviewer elaborated the simplified incorporation of response degradation, e.g., as noted in the report, when the wind increased to one knot from yellow value to a red value, the response efficiency did not change from 100% to 0%; nor did it change when two factors changed from green to yellow values. The reviewer commented that the authors used this arbitrary approach that indicated at a certain time of the year a tactic should not be included in a response, when it might actually

	be effective; therefore, this approach would incorrectly influence the planners to provide the responders with the appropriate tools necessary for an effective response. ⁵
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4	<i>Were the environmental data sources used for the response gap analysis clearly described and adequately characterized (Sections 3 and 4)? Is there any other publically available data that should have been considered?</i>
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Comments:	<p>The reviewers agreed that the data and data sources were clearly described in Sections 3 and 4, and acknowledged the overall paucity of data for offshore Chukchi and Beaufort Sea area, but strongly suggested to supplement the data. The comments on environmental data sources and characterization of data sources are described below:</p> <p>One reviewer expressed his disappointment regarding the data sources, especially Figure 4 in Section 4.1, which presented only the partial correlation between offshore wind conditions and the airport site. The reviewer commented that the discussion in Section 10 on understanding the impact of utilizing the airport wind data to develop the offshore sea state condition was not substantial. The reviewer emphasized the profound effect of the wind direction and the presence of ice would have on the wind-generated waves, and that the study did not provide any discussion or correction on this topic.</p> <p>Another reviewer commented that it seems highly unlikely that the detailed metadata (position, time of operation, instruments, etc.) on data buoys neither exists at data originator nor at NODC. The reviewer suspected that the data might be available from moorings and cruise data from research vessels on the two sea areas for the 5-year period being analyzed in the report. The reviewer also suggested supplementing the data with satellite remote sensing data on SST and sea ice. The reviewer questioned the rationale for selecting the two points for the ice concentration, and suggested utilizing the ice concentration in an area, as both oil and ice are drifting and driven by wind and ocean currents. The reviewer recommended displaying the real data values as more interesting instead of presenting the monthly mean values from the 5-year data, when hourly values were used for RGI analysis. The reviewer advised that a discussion on the quality of data being used in the study would be beneficial.</p> <p>Another reviewer commented that the authors did not describe in detail the reasons for using one-hour increments of the environmental input data in the analysis, and the applicability of the hourly increments. The reviewer mentioned that the authors acknowledged in Section 2.5 the lack of consecutive time increments to apply the different tactics. The reviewer stated that the environmental data do not support the reason for this approach, and recommended utilizing a modified approach for utilizing the data.</p> <p>Another reviewer suggested that, if available, the anecdotal data from local pilots be used to compare the (Instrument Flight Rules) IFR/ (Visual Flight Rules) VFR conditions offshore to those that are recorded in the local airports. The reviewer</p>
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commented that the onshore wind, temperature, and visibility data from the onshore airport facilities were complete for the 5-year period; however, the offshore buoy data were limited to 128 days for two summer periods. The reviewer stated that the report lacked documenting these offshore data measurements impeding the interpretation of data.

The reviewer recognized the efforts of the authors in identifying the sources of sea state data, with numerous experts and organization identified. The reviewer questioned if the data were available from two other sources, such as the Canadian Ice Service and Environment Canada.

In addition, the reviewer discussed the issue of visibility, which the report correctly identified as being different at the airport than on water (i.e., the temperature of land mass heats/cool faster than water, which affects the dew point and formation of fog). The report did not take into account the significant amount of transit time from airports to spill locations for response operations due to visibility issues. The reviewer reiterated the importance of visibility in dispersant application and monitoring, and suggested that additional analysis would be beneficial. The reviewer commented that the issue of aircraft icing was not included in the report, and recommended that additional information would be helpful in providing real time estimates during which the response tactics requiring an aircraft would be prevented.

5 *Were the results of the response gap analysis (Sections 5, 6, 7, 8) for each tactic (i.e., open-water mechanical recovery, application of dispersants, and in-situ burning) appropriate and clearly described? Was the RGI and associated graphical outputs clearly presented?*

Comments: The reviewers agreed that the description of response gap analysis results and limitations were well presented, but had some comments and suggestions. Discussed below are the comments on open-water mechanical recovery, application of dispersants, in-situ burning, and clarification requested in understanding the terminologies in Sections 5, 6, 7, 8 of the report.

Mechanical Recovery

In reviewing Table 12 in Section 6 (Mechanical Recovery), one reviewer questioned the rationale behind the impairment of offshore mechanical recovery device due to the wind speed being recorded elsewhere. The reviewer commented that Table 12 did not use wind as a parameter, even though Section 6.2 stated that “winds in excess of 20 knots begin to degrade the effectiveness of open-water recovery systems.”³ Another reviewer commented that Section 6.1 (Overview of Tactic) described the modified tactics of mechanical recovery, but was not included in the analysis.²

Application of Dispersants

In the application of dispersants, one reviewer mentioned if mixing energy is

considered, then it is likely to slow the response and reduce the efficiency of the tactic. The reviewer noted that the mixing energy might not be significant in this study, because it is prevalent during transitional ice conditions, which is relatively shorter in the Arctic regions. The reviewer commented that Section 7.2 (Response Limits) discussed the potential effects of various factors (such as, water temperature, pH, and salinity) on the dispersants, but not on their application; therefore, a tactic that is applied might not be effective. The reviewer further mentioned the concept of net environment benefit from the application of dispersants.²

In-situ Burning

One reviewer commented that a short window of opportunity would be one of the major disadvantages with the in-situ burning, and suggested that analyzing the characteristics of oil might be beneficial for contingency planning. In addition, the reviewer discussed other plausible considerations for improving visibility with infrared cameras and oil detection radar, and shared experiences of successful mechanical recovery operations and dispersant application conducted in darkness in Norway.²

Terminology

One reviewer commented on the lack of explicit references throughout the report when the authors stated “supported by literature.”⁴

Another reviewer noted a discrepancy in the vessel dispersants statistics (18% Chukchi and 20% Beaufort) in Section 5 (2nd paragraph) with those in Section 7 (Figure 17). In Section 6.2 (Table 12), Section 7.2 (Tables 14 and 15), and Section 8.3 (Tables 17 and 18), on response limits, the reviewer recommended replacing the paragraph discussing the wind/sea state, with wind-generated effect on sea state. As mentioned earlier in charge question number 2, the reviewer reiterated that the yellow/red color descriptions must be clearly defined in Tables 12, 14, 15, 17, and 18. The reviewer specifically stated that the yellow limit for ice appeared to be incorrect in Tables 14 and 15, and recommended revisions. The reviewer indicated the need for an explanation on how green and red limits were determined in Tables 17 and 18 (Ice Factor).⁵

6	<i>Were there any critical results or limitations not discussed or adequately addressed in Sections 5, 6, 7, and 8 of the report?</i>
Comments:	<p>Two of the reviewers provided their critique on results or limitations pertaining to Sections 5, 6, 7, and 8 in the previous charge question number 5. The additional comments made by the other three reviewers are synthesized here. Discussed below are the comments on open-water mechanical recovery, application of dispersants, in-situ burning.</p> <p><u>Mechanical Recovery</u></p>

	<p>One reviewer commented on the inadequacy of using wind speed measurement as a surrogate for wave height, which was a limiting factor in mechanical recovery. The reviewer stated that there are other factors such as modal periods and steepness factors along with the wave height that might impact the effectiveness, but were not discussed in the report. The reviewer stated that authors understated the potential availability of mechanical recovery in the summer season, because they selected 15 knots wind speed in the report as the “mechanical recovery not possible” limit. The reviewer stated that the authors discussed the effect of temperature on mechanical recovery effectiveness, but was limited to icing problems; therefore, the reviewer recommended recognizing the effect of water temperature on the spilled product. In addition, the reviewer commented that the viscosity of oil would affect the effectiveness of dispersants, and performance of mechanical devices and pumps.³</p> <p><u>Application of Dispersants</u></p> <p>One reviewer questioned the availability of vessels to provide the necessary mixing energy needed for effective dispersions in relation to large spills, which was not discussed in the report. The report enunciated the presence of ice on reducing mixing energy, and that utilizing vessel propellers would introduce energy into the environment to facilitate dispersions. The reviewer commented that this approach might be appropriate and applicable for small spills in a limited area, but questioned the approach for large spills in extended areas.¹</p> <p><u>In-situ Burning</u></p> <p>One reviewer was surprised with the vessel in-situ burning results being effective during winter, which would have required icebreakers. The reviewer commented that the report did not discuss anything about the icebreakers, perhaps as the report assumed that all relevant facilities would be in place.⁴</p> <p><u>Additional Comments</u></p> <p>One reviewer reiterated the importance of considering visibility issue (as mentioned earlier in charge question number 4) with aircraft operations. The reviewer suggested including the issue of icing conditions associated with aircraft operation in the report, which was not discussed. The report focused on helicopter applications due to enhanced maneuverability, but the reviewer recommended examining the limitations on endurance offshore in addition to providing associated vessel support. The reviewer acknowledged that the study addressed the environmental limitations associated with in-situ burning appropriately.¹</p>
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7	<i>Are the findings and overall interpretation of the results clearly discussed (Section 9)?</i>
Comments:	There were varying responses to this question, two reviewers did not feel that the findings and overall interpretation of the results were clearly discussed (Section 9), while the other three reviewers thought otherwise.

	<p>One reviewer suggested that the discussion on tactics that were not considered were described in Section 9.1 instead of being included either in the Executive Summary or Introduction sections. The reviewer indicated a discrepancy in the summer “Dispersant from Vessels” numbers between Figures 17 and 21. The reviewer also questioned the choice to not include the tactic “Dispersants from Aircraft” in the most feasible tactics summer column, which is 50% of the time feasible/possible.⁵ Another reviewer suggested presenting the individual seasonal factors within the discussion of the response tactics rather than in this low-resolution summary graph in Figure 22 of the report.³</p> <p>Another reviewer commented that the study lacked discussion on oil characteristics and oil weathering, window of opportunity, and duration of operational window for different tactics, that might lead to slightly optimistic evaluation of tactics (application of dispersants and in-situ burning).²</p> <p>Another reviewer commended the authors for providing the graphical illustration on how the various environmental factors prevented the use of various response tactics on page 62 (Individual-Factor Response Gaps for the Chukchi Sea). The reviewer acknowledged that the report emphasized the need for continuous environmental data and well documented and quantified limits that would strengthen the results of the study. The reviewer questioned who would be responsible for deploying the infrastructure required for collecting and storing the data. In addition, the reviewer commented that there might be legislative and regulatory impediments while conducting a large-scale tests and real-world exercises for better quantification of limits for various responses, as identified in the report.¹</p>
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8	<p><i>Are the conclusions (Section 11) logical and appropriate based on the results? Are there any additional conclusions that could be drawn?</i></p>
Comments:	<p>There were two reviewers who disagreed, and the other three reviewers agreed that the conclusions were logical and appropriate. Among the reviewers who disagreed, one reviewer stated that Section 11 was deficient and did not provide any additional value. The reviewer suggested combining Sections 9, 10, 11 into one section called conclusions. The reviewer also suggested populating this section with conclusions made during the analysis and including a comprehensive discussion about the results. Furthermore, this reviewer recommended adding another paragraph on future developments needed to enhance the usefulness and reliability of this tool.</p> <p>The other reviewer who disagreed commented that the authors discussed for the first time the various speed of occurrence of seasonal changes in the last section of the report. The report stated that in the fall season operational conditions may degrade quickly. The reviewer commented on the discussion and stated it to be irrelevant in this section. In addition, the reviewer suggested incorporating longer durations than one hour in the analytical process, if the rapid transition to winter season was a significant finding in the report.</p> <p>Among the reviewers who agreed with the conclusions, one reviewer stated that it is the presence of sea ice that significantly affects the applicability of certain response</p>

tactics in the Arctic versus temperate environments. Another reviewer recommended stating in the report that planning an oil spill response in the Arctic would be conducted in compliance with applicable state and Federal regulations. The reviewer commented that the last paragraph seemed incomplete, and suggested adding a sentence that planning the appropriate tactics would vary during spring and fall transition time.

9

Does this report present sufficient new data and knowledge, and are the findings useful for informing oil spill response planning?

In general, the reviewers agreed that the report provided sufficient new data and knowledge, and the findings were useful for informing oil spill response planning. Reviewers provided their comments to supplement the environmental data and response tactics which are described below.

Environmental Data

One reviewer parsed this question into three parts, and stated that the report did not provide sufficient new data, but provided sufficient new knowledge, and the findings could be evaluated as a qualitative tool for skilled planners. The reviewer stated that unless the data were supplemented with additional relevant data and rigorous analysis, it cannot be used as a quantitative tool for planning purposes.³

Another reviewer emphasized the importance of assessing the following variables: characteristics of oil, environmental conditions, knowledge of environmental sensitivities, and availability of infrastructure, resources, and trained personnel in any major oil spill.¹

Comments:

Another reviewer stated that the best approach to supplement the data would be in conducting in-situ observations with geographical relevance, time, and space resolution; however, it might be an impediment in the Arctic region. Therefore, the reviewer suggested utilizing an appropriate model data. The reviewer also commented that the results of the report would not only provide information on planning and defining security measures for exploring and extracting oil in the Arctic region, but also on the relevance and feasibility of such undertakings.⁴

Response Tactics

In general the reviewers agreed that the report identified and discussed the limitations of response tactics, which were appropriate during specific seasons. One reviewer stated that the findings would be beneficial in facilitating spill response planning.¹

Another reviewer commented that the environmental limitations affecting the spill response operations that were identified in the report have been known to the regulators and facility, vessel, and aircraft operators. The reviewer stated that the report provides the spill response planners with resources that would be effective during summer and winter seasons.⁵

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Another reviewer stated that understanding what the response is aiming to protect and the feasibility of logistics in remote locations would be beneficial in choosing a tactic, and putting together a “toolkit,” and preparing a successful spill response plan.²

Overall, the reviewers acknowledged that the report provided useful information on the environmental limitations with regard to response tactics applicable during summer and winter seasons in the Arctic region.

4. PEER REVIEWER COMMENTS BY CHARGE QUESTIONS

4.1 General Impressions

General Impressions	
<i>Silje Berger</i>	<p>The report “Estimating an Oil Spill Response Gap for the US Arctic Ocean” provides an overall impression of the environmental conditions which might enable or preclude different response tactics in the study area, based on historic records of environmental conditions. It takes a schematic approach to compare the limitations to three different response tactics. It also visualizes substantial differences throughout the year.</p> <p>The report is well written and the information should be easy accessible to stakeholders and other audience with some experience in the field. Graphical presentation contributes well to the understanding of the results.</p> <p>The environmental data from the study area are relatively scarce, but the discussion of the limitations in the data basis, provides the reader with an understanding of which precautions should be taken in the use of the results. Furthermore, the report addresses and discusses the most important shortcomings of the methods, adding to the readers understanding of what may be extracted from the report, and what better not be derived from the results.</p> <p>My main concerns regarding the method are that oil characteristics and weathering, window of opportunity and duration of the operational window for the different tactics is not taken into account. Efficiency of the different tactics is not only influenced by the environmental conditions directly, but the environment also impacts on the oil and oil weathering. This may also be crucial for the effectiveness of the different tactics.</p> <p>All in all, the report serves as an interesting piece of the big picture for contingency planning for the area. The report provides a good impression of environmental limitations to the regarded response tactics. The method is adequate to visualize seasonal variation and relative differences between the different tactics.</p>
<i>Carl Brown</i>	<p>The report does a good job in estimating the oil spill response gap for the U.S. Arctic Ocean, specifically for the Chukchi and Beaufort Sea areas. The report clearly identifies the objective of estimating how often a specific response tactic would be precluded based on environmental conditions.</p> <p>It is clear that the authors have examined a large number of data sets and consulted with relevant subject matter experts and organizations.</p> <p>The methodology used in the study is based largely on earlier studies done by the same authors in nearby geographic locations with some modifications and developments. The report identifies the available environmental data and the limits imposed by a lack of data and data quality in some cases. Environmental data shortfalls are not an uncommon circumstance in remote Arctic locations. The report carefully identifies and explains all of the assumptions that are made with respect to</p>

the available data and which environmental conditions are or not included in the analysis. Not all possible response tactics are included in the evaluation and those which are not are clearly identified. The response gap does not estimate the extent to which the response tactic would be effective, nor does it discuss how the type of oil or environmental weathering might reduce response effectiveness. The time required to operationalize response assets and transit to the spill location are not considered in the study.

The textual and graphical representations of the results of the study facilitate the rapid understanding of which response tactics are appropriate and under which conditions during the summer and winter seasons.

The conclusions of the report are logical and appropriate based on the available environmental data and documented limits. The results provide a useful tool for response planners to evaluate their proposed spill response approach and selection of response tactics depending on the season and existing environmental conditions.

Differences in response tactics between summer and winter seasons are significant, with on-water vessel activities being favored in the summer and limited options being available in the winter seasons. The presence of sea ice significantly affects the applicability of certain response tactics. It is this environmental condition that is the major difference for Arctic oil spill response relative to response in more temperate environments.

Erik Buch

The Response Gap Analysis carried out in this report is very interesting, because it gives a clear indication of limitation that exists for oil combatting in the harsh environment of the Arctic Ocean and therefore it serves as a good tool for decision makers responsible for planning and executing oil combatting. The results are also of importance to the ongoing debate on the relevance and feasibility of exploring and extracting oil in the Arctic region and gives relevant information for planning and defining security measures for such activities.

The quality of the analysis is however not better than the data used for the analysis. It is a well-known fact that meteorological and oceanographic observations are sparse in the Arctic Region. This is also displayed clearly in this report where there hardly exists any relevant data from the ocean areas in question. I am therefore surprised that the authors have not used model outputs instead. The benefit of using model re-analysis data would have been:

- Long time series of all relevant meteorological and oceanographic parameters from the offshore areas;
- The analysis could have covered several locations in the two sea areas to investigate regional differences;
- It could have opened the possibility to include ocean currents in the analysis. The current itself will not be a limiting factor but oceans currents are important to the drift of ice and oil and therefore play a role.

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	<p>The quality of the models off course is an issue i.e., how uncertain are the model output? However, most operational meteorological and oceanographic models have been well validated - meaning that there quality stamps on the model output; but again this validation is not better than the available observation which , as mentioned above, are limited in the Arctic region. Nevertheless, observational data also have a quality issue depending on instrumentation, calibration periodicity etc, and this is not discussed in the report. It, therefore, is my belief that the analysis would have benefited from using model data as a supplement to observations.</p> <p>The analysis and discussion of the various combatting methods and their limitations to environmental conditions are detailed and takes many practicalities into account and the results are very interesting and uncertainties discussed in a proper manner. It is also very good that the author underline that the result are achieved under the assumption that all practical arrangements (ships, airplanes, helicopter, gear, people etc) are ready and available – which probably never will be the case. So therefore the result presented in the report is ideal.</p>
<p><i>William Hutmacher</i></p>	<p>The report should be a helpful tool that spill response planners may use to help determine which spill response tactics and their associated resources may be most effective during the summer and winter seasons in the Arctic. However, the actual planning to choose tactics will still have to be in accordance with the current federal and state regulations. The environmental limitations regarding specific spill response tactics are mostly known but have not been compiled in a response gap analysis for the Arctic like this before. The type of spill response tactic used in the analysis was limited in number but the reasoning for this limitation was not discussed at all. Was this limitation prescribed by BSEE? Terminology in the report regarding tactic “effectiveness” was not clear. Terms such as “ineffective,” “impossible,” “possible,” “feasible,” “not possible,” “not feasible,” “most feasible,” “impaired,” “precluded” need to be defined, explained, or replaced. How the response gap index is applied (Table 1) in determining “most feasible,” “impaired,” “impossible,” “precluded” tactics is not explained satisfactorily. It seems to be an arbitrary approach that suggests elimination of a response tactic during a specific season when it may actually be somewhat effective.</p>
<p><i>Paul Smith</i></p>	<p>I commend the authors for attempting to extrapolate response gap indices from such thin data. I concur in their choice of parameters that would limit response operations with one exception: the omission of temperature effect on the recoverability of spilled oil.</p> <p>I do not necessarily concur in their methods of extrapolation or their choice of surrogates. The attempts to correlate airport wind data to offshore sea conditions lacked rigor. The absence of any consideration of (or even discussion of) the effect of ice cover and wind duration on sea state is disappointing. It resulted in what I believe to be an unrealistically low wind speed limit to mechanical recovery.</p> <p>Their conclusions with regard to the order-of-finish of total proportion of time where the different response tactics are feasible align with my own intuition or “gut feel.” For instance, I believe that conditions suitable for dispersant application from</p>

vessels will be more prevalent than those for mechanical recovery. However, I find it difficult to believe that such conditions exist for 82% of the time in the summer. Perhaps what I perceive to be an overstatement of “availability” is a result of their choice to parse the data into one-hour increments. A suitable window of opportunity to mount any useful response operation must be longer than that - to my view, 3 hours should be the minimum.

I found some of the discussion to include tangential statements that are unsubstantiated and of little value to the objectives of the study. For instance, within Section 8, it is stated that, “A heli-torch may be used to ensure rapid ignition...” It is simply not true that heli-torches ensure rapid ignition. They are just another tool to try to establish a self-sustaining burn. There is a similar unsubstantiated statement later in the section that characterizes burn residue from “most burns.” Such self-serving commentary, possessing little relationship to the objectives of the report should be removed. Or, if left in, they should be properly supported.

4.2 Responses to Charge Questions

1	<i>Are the objectives of the report clearly defined? If not, what are your recommendations for improving the description of objectives?</i>
<i>Silje Berger</i>	<p>The objectives of the study are mainly outlined in the introduction, and further specified in paragraph 2.1 “Scope of this Analysis.”</p> <p>As far as I am concerned, it is brought clearly to the point in the first paragraph, stating that the response gap analysis estimates how often a particular response tactic is likely to be precluded based on historic environmental conditions.</p> <p>For an outside reader it would be informative to have some short background information about the context of the study and the study area, like for instance:</p> <ul style="list-style-type: none"> ▪ What are the possible sources of oil spills (drilling activities, pipelines, shipping routes, etc)? ▪ Is the study related to the planning of specific activities? ▪ What are the environmental resources at risk? <p>The BSEE surely is very well aware of the context, so this would apply for other readers who might use the results of the report (e.g., external researchers, companies that take the analysis into account in their planning, international audience).</p>
<i>Carl Brown</i>	<p>The stated objectives are to undertake a first response gap analysis of the U.S. Arctic Ocean in order to estimate how often a particular response tactic would be precluded based strictly on historic environmental conditions. The gap analysis focuses on the impact of environmental conditions on the ability to deploy a response. The report does not consider equipment and trained personnel, assuming that the resources are available both in-region and from other locations. The report identifies the data shortfalls, and acknowledges that local conditions may be different from conditions where data are available.</p>
<i>Erik Buch</i>	<p>The objectives are not clearly expressed in on paragraph at the beginning of the report – which could have been desirable. However, after having read Chapter 1 and 2 one is not in doubt on what the purpose of the exercise is.</p>
<i>William Hutmacher</i>	<p>No. Neither the Executive Summary nor Sect 1 specifically states the objective(s) of the report. The Exec Summary and/or Sect 1 should specifically state the objective/task assigned by the BSEE. What exactly did BSEE task them to report on? For example, they could use the one in the Project History & Objectives section of the Peer Review Charge Document, i.e., BSEE contracted Nuka Research “to perform an oil spill response gap analysis for three areas in the U.S. Arctic Beaufort and Chukchi Seas.” If BSEE was more specific in its definition of oil spill response gap analysis, then that should be included also.</p>
<i>Paul Smith</i>	<p>The objectives are clearly defined.</p>

2	<p><i>Was the methodology (Section 2) used for the responses gap analysis appropriately designed and clearly described? Were there any apparent weaknesses or gaps with the approach used to develop the environmental limits and estimate the Response Gap Index (RGI)?</i></p>
<i>Silje Berger</i>	<p>Developing environmental limits for the different tactics is a difficult task due to limited documentation. It is difficult to verify these limits, amongst others for the reasons mentioned in section 2.5. There are also different approaches to evaluate the efficiency from experience (past spills), and documentation – if available at all – leaves room for different interpretations. The approach to review literature and subsequently vet the findings with experts seems to be the best achievable approach. However, environmental limitations will inevitably remain subject to discussion among experts, analysts, responders as well as equipment manufacturers.</p> <p>The methodology is explained in generally well understandable terms. Description of the program could be more extensive, i.e., by adding a reference to a closer description of how the calculation is performed, if this is published somewhere else. From this description I assume that it is based on a simple cut-off when the limit value is exceeded.</p>
<i>Carl Brown</i>	<p>The methodology used was developed for earlier studies in Prince William Sound, Alaska, northern British Columbia, the Aleutian Islands and the Canadian Beaufort Sea. The most appropriate spill response tactics were identified for study and the relevant environmental factors selected. The response gaps were summarized both textually as a percentage of time during which the response tactic would be precluded (Response Gap Index, RGI) and graphically in colors (Green – response possible, or Red – response not possible or effective). When environmental conditions impact operations but do not prevent them, they are identified as Yellow. Response tactics can be precluded by one environmental condition or a combination of conditions. Two or more Yellow environmental conditions would lead to a Red RGI – response not possible or effective.</p> <p>The methodology identified the limited available data for relevant environmental conditions, establishes operational limits for environment factors based on available and professional judgment, and compared the operational limits with historic data and estimated the Response Gap Index.</p> <p>The graphical representation depicts seasonal variations and is nuanced to show shading of green and red to identify degradation of response capability. This graphical representation provides a rapid way to identify the appropriateness of a specific response tactic both seasonally (x-axis, generally better in summer) and percentage wise (y-axis).</p> <p>The methodology does have some inherent weaknesses including; limited data availability particularly for the offshore environment, it makes assumptions about equipment and personnel availability, does not provide details on the custom program used to calculate the Response Gap Index (have details of the program been published and/or peer-reviewed?) The report identifies that only complete datasets are used to calculate the RGI and graphical outputs (i.e. if one or more</p>

	environmental conditions are missing for a given hour, the results are not included for that particular hour).
<i>Erik Buch</i>	<p>The concept and methodology behind RGI is well described – the section would benefit from a tightening up – there are some repetitions. Specific comments to section 2:</p> <ul style="list-style-type: none"> ▪ Use of model data as described above. ▪ Cannot understand why the authors restrict themselves to a 5 year period when there is available meteorological data for a much longer period. Could have opened up for an analysis of changes over time and especially to show and document if climate change has any effect on this particular subject. Now we are left with a statement on climate change but no idea if it affects the RGI and how much. ▪ Section 2.3 is not very concrete only references to other publications – it would have been good with a description on the methods and research behind the used limits.
<i>William Hutmacher</i>	<p>How was the scope of the analysis determined, specifically with respect to the spill response tactics included and those not included? Why were tactics such as underwater dispersant injection, on-ice oil removal, and under-ice oil removal not included? If the tactics selected for the study were predetermined by BSEE, then that should be stated. If not, discuss the reasoning behind the limitation of tactics studied.</p> <p>The Yellow/Red environmental conditions need additional explanation and distinction. As stated, the Yellow condition is “expected to impact the operations or their effectiveness.” What does “impact the operations or their effectiveness” mean? What is the measurement used to determine the level of impact on operations or their effectiveness?</p> <p>The Red condition “precludes deployment or response ineffective.” While “precludes deployment” is a clear measure, “response ineffective” is not. Does Red mean 100% ineffective? What is the difference between Yellow condition’s “impact...their effectiveness” and Red condition’s “response ineffective”?</p> <p>Also, in all the response limit tables (Tables 12, 14, 15, 17, 18), the Red heading says “Response: Not Possible/Effective.” The condition descriptions in Sect 2.2.2, they should probably say “Response: Precludes Deployment or Response Ineffective, or Red should say Response: Not Possible (see para 6 below).</p> <p>Table 1. Applying the Response Gap Index. This table needs further explanation in Sect 2.2.3 with respect to “If two or more factors are ruled Yellow, then the RGI is Red.” Why should two Yellow factors result in a Red classification? Yellow means that the environmental factors are “expected to impact the operations or their effectiveness,” not prevent them. This could unnecessarily limit consideration of a</p>

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	tactic that could have some degree of effectiveness over a greater part of the year.
Paul Smith	While the analysis methodology was clearly defined, the environmental limits selected were not. Without reading the four references listed in section 2.3, I cannot opine as to whether they have selected the “right” ice limits. As stated elsewhere in this review, I believe that their selection of wind speed limit, particularly as it relates to mechanical recovery, is weakly supported.

3	<i>Are the limitations of the approach (Section 2.5) clearly identified and described?</i>
Silje Berger	<p>Section 2.5 highlights limitations to the approach in a clear and understandable way.</p> <p>A simplified incorporation of response degradation is mentioned, and I want to highlight this point, because it is important to understand the consequence of this simplification. The transition from effective to not effective is not very well resolved in this approach. A simple yes or no answer is often desirable to stakeholders; however, a yes/no answer do not entirely reflect the complexity of environmental limitations to different tactics.</p> <p>An apparent weakness is that oil characteristics and weathering of the oil is not taken into account. Efficiency of the different tactics is not only influenced by the environmental conditions directly, but the environment also impacts on the oil and oil weathering. This may also be crucial for the effectiveness of the different tactics. For instance do temperature and sea state influence on the viscosity of an oil slick, and hence on the applicability of a certain tactic, like the efficiency of dispersants.</p>
Carl Brown	<p>The report does a good job of identifying limitations of the approach. The limitations are identified by acknowledging the assumptions made, for example, it is assumed that the response tactic is always available during favorable environmental conditions; this would lead to an overestimation of response capability. The response gap does not estimate the extent to which the response tactic would be effective (e.g., mechanical recovery rate or in-situ burn efficiency). The approach does not consider oil type, or the effects of environmental weathering on the oil (evaporation, emulsification etc.) which could influence the effectiveness of a particular response tactic.</p> <p>The report acknowledges that in some cases the quality and availability of environmental data are limited or not available (a frequent occurrence in remote locations). In some cases, data are not available for a particular location and the analysis then relies on onshore data to estimate conditions offshore. The report acknowledges that offshore conditions might be significantly different than onshore conditions.</p> <p>The report relies on a hindcast of environmental data to inform future conditions. Given the recent rapid changes in the Arctic climate, the hindcast was based on the prior 5 years of conditions in spite of the fact that much longer data records are available. This approach assumes that environmental conditions will not revert to</p>

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	<p>the historical normal (i.e., colder) in the near future.</p> <p>The report acknowledges the lack of good documentation on response limits. In addition, much of the data on oil spill response equipment performance is based on bench or test tank studies instead of real-world tests. This approach would overestimate the effectiveness of the response tactic. The report identifies the need to validate response limit assumptions. The report assumes a gradual degradation of response tactics, realizing that response efficiency does not go from 100% to 0% when environmental conditions change from a yellow to red value.</p> <p>The RGI incorporates environmental data into hourly conditions (either from direct measurements or interpolated from weekly data). It does not consider whether there are good environment conditions of sufficient duration to mobilize, deploy and demobilize response tactics. This would lead to an overestimate of response tactic capability.</p>
Erik Buch	The limitations are generally clearly identified and described; I do however disagree with some of the choices made as mentioned above.
William Hutmacher	As noted in the paragraph 2, the Yellow/Red condition distinction and the basis for the critical Table 1 (Applying the Response Gap Index) are not explained satisfactorily. In “Simplified incorporation of response degradation,” it is noted that “response efficiency does not go from 100% to 0% as wind increases one knot from a Yellow value to a Red value.” Nor does response efficiency necessarily go from 100% to 0% when two of the factors change from Green to Yellow values. This arbitrary approach would seem to indicate that a tactic should not be included in a response at a certain time of year when it may actually be somewhat effective. This may have a negative effect on planners trying to give responders all the potential tools that might add to an effective response.
Paul Smith	They are clearly identified, but not necessarily clearly described. For instance, the quality and availability of environmental data is limited. The reader is referred to Appendix A for the explanation of how they managed to correlate onshore data to offshore conditions. Appendix A was disappointing in its ability to provide either a correlation or an explanation.

4	<i>Were the environmental data sources used for the response gap analysis clearly described and adequately characterized (Sections 3 and 4)? Is there any other publically available data that should have been considered?</i>
Silje Berger	<p>Section 4 and 5 as well as the appendices describe the environmental data used in the study in clear terms. The report also addresses the very limited access to offshore measurements and the resulting uncertainties. Improved offshore data would certainly add to the report’s soundness, but the report provides the overall picture of operational challenges of an oil spill response in the area.</p> <p>The arguments for using one-hour increments of the environmental input data in the analysis are not described in much detail. It is not obvious why hourly increments</p>

	<p>are more applicable than for instance daily increments, especially taking into account that the discussion focuses on the larger picture of summer versus winter conditions. Furthermore, it is emphasized by the authors themselves in section 2.5 that they do not consider if there are enough consecutive time increments to apply the different tactics. As far as I am concerned, the reason for this approach does not lie in the environmental data themselves and the data would support a modified approach addressing this as well.</p>
<p>Carl Brown</p>	<p>As noted earlier, there is a paucity of environmental data for the offshore Chukchi and Beaufort Sea areas. Those offshore weather buoy data that are available are limited to short periods of time in the summer for a couple of years. Data from onshore locations (airports) are used extensively. Is it possible that anecdotal data are available from local pilots to compare IFR/VFR conditions offshore to those recorded at local airports? Sea ice coverage is from weekly charts, interpreted from satellite data by ice analysis experts. Daily ice concentrations are extrapolated from weekly data assuming a linear transition between data points for each week. Actual sea ice data are taken from only two locations approximately 270 miles apart.</p> <p>Data for onshore wind, air temperature and visibility data from onshore airport facilities are shown to be very complete over the 5 year period. This is in stark contrast to the availability of offshore buoy data which is limited to a total of 128 days during two summers. These offshore data measurements are not well documented, so data interpretation is difficult. One important observation is that there is more variability in the offshore buoy wind direction and wind speed.</p> <p>The efforts to identify sources of sea state data were extensive, with numerous experts and organizations identified. Are data available from sources such as the Canadian Ice Service, Environment Canada? Sea states were estimated using wind and ice dampening effects on waves.</p> <p>Visibility is estimated in three ways; horizontal visibility, cloud ceiling, and daylight/night at local airports. The horizontal visibility is related to airspace flight rules (visual flight rules, VFR) which require visibility of at least one mile. This provides context for possible impact on response operations. The report correctly identifies that visibility at the airport can be very different from that on the water (i.e., land mass temperatures heat/cool faster than water – affecting the dew point and fog formation). Although it is not considered in the report, it is important to recognize that significant periods of time might be needed for transit from airports to spill locations. Visibility is very important for dispersant application and monitoring, additional analysis would be beneficial.</p> <p>Aircraft icing was not included in the analysis yet this information is essential for safe and effective spill response operations. Additional study would be beneficial and would lead to more realistic estimates of times during which response tactics requiring aircraft would be precluded.</p>
<p>Erik Buch</p>	<p>The data and the data sources are well described (several times). I have the</p>

	<p>following specific comments:</p> <ul style="list-style-type: none"> ▪ I find it hard to believe that there do not exist more detailed metadata (position, time of operation, instruments etc.) on the data buoys neither at the data originators nor at NODC. ▪ I would suspect that there exist some cruise data from research vessels from the two sea areas from the 5 year period used in this analysis, maybe also data from moorings. ▪ Ice concentrations are based on two selected points: <ul style="list-style-type: none"> ○ On what basis are they selected? ○ I think it would have been better to use ice concentration in an area, since both oil and ice is drifting driven by wind and ocean currents. ▪ Satellite remote sensing data on SST and sea ice exists and could have supplemented the data used. ▪ It would have been desirable with a discussion on the quality of the data used. ▪ In the presentation and discussion of data (Cap.4) it is relatively uninteresting to see presentation of monthly mean values based on the 5 years when the subsequent RGI analysis uses hourly values. It would have been more interesting to have a display of real values.
William Hutmacher	The descriptions were clear and understandable. Not aware of other publicly available data.
Paul Smith	<p>The data sources were clearly defined and admittedly disappointing. I do not know if additional data exists.</p> <p>Again, support for the selection of surrogate data was weak. For instance, figure 4 in section 4.1 seems to present only partial correlation between offshore wind conditions and those found at the airport sites used. Winds from the SSE on the offshore buoy wind roses are not reflected in the Barrow, Wainright, or Prudhoe wind roses. The text later refers the reader to section 10 to learn of the impact of using airport wind data to develop offshore sea state conditions. Discussion found there was not illuminating. Wind direction (and the presence of ice) would have a profound effect on the effective fetch for wind-generated waves. There was no discussion or correction attempted for this.</p>

5	<p><i>Were the results of the response gap analysis (Sections 5, 6, 7, 8) for each tactic (i.e., open-water mechanical recovery, application of dispersants, and in-situ burning) appropriate and clearly described? Was the RGI and associated graphical outputs clearly presented?</i></p>
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Silje Berger

The results are generally well described and the graphical presentation is very informative to the reader.

Open-water mechanical recovery: Modified tactics of mechanical recovery are describe in section 6.1 “overview of tactic,” but not included in the analysis.

It is noted, that the limits of mechanical recovery are better described in the literature, this may also reflect that there is more experience with this tactic, and hence the limits has been explored to a greater extent, both in research, but particularly resulting from experience from past spills.

Application of dispersants: The limits for sea state and wind have no minimum value, and the authors present a reasonable argumentation for this assumption. However, if it is necessary to add mixing energy, it is likely that this will slow the response and hence lead to reduced overall efficiency of the tactic. This is noted as a general comment. This is particularly relevant during transitional ice conditions, which is present only short periods of the year in the study area, so this is probably not of great significance in this study.

As mentioned in section 7.2 “Response Limits” water temperature, pH and salinity may affect the effectiveness of dispersants, but not their application. This exemplifies that the fact that a tactic is possible to apply, does not necessarily mean that it is effective. Furthermore, it is neither necessarily so that it causes the least environmental damage (often referred to as net environmental benefit).

In-situ burning: One of the major drawbacks with the tactic in-situ burning may be a short window of opportunity. As oil characteristics are not included in the analysis this is not taken into account, but it might be an important issue for contingency planning.

Some additional considerations based on my experience:

- The limitations due to visibility might to some extent be overcome by technology enabling effective vessel operations in low visibility conditions, such as infrared cameras and oil detection radar.
- There is some (although limited) experience of successful mechanical recovery operations in darkness as well as dispersant application in darkness from Norway.
- During the response operations after the grounding of the vessel MV Godafoss in Norwegian waters in 2011 effective mechanical recovery operations were run in darkness (during nighttime) using detection equipment on board a Norwegian Coast Guard vessel to target the oil. The weather during this response was characterized by temperatures between -10 and -20 °C, but almost no wind and a calm sea state. On the other hand, already low ice concentrations turned out to reduce effectiveness of mechanical recovery substantially in some locations, in other locations the ice acted as a barrier to the oil. The consistence and

	<p>characteristics of the ice determined how it affected the recovery operation.</p> <ul style="list-style-type: none"> ▪ Dispersant application in darkness took place after an oil spill at “Draugen”- oilfield in the Norwegian Sea in 2006. Dispersants were applied from a vessel equipped with spraying booms, with aerial guidance by a surveillance aircraft. Aerial guidance was crucial for the correct application of the dispersant.
<p><i>Carl Brown</i></p>	<p>As expected, all response tactics are more likely to be feasible in summer conditions than in winter.</p> <p>Mechanical recovery is reported to be possible in open-water conditions with waves of up to 6 feet and in winds of up to 30 knots. Limitations posed by environmental conditions such as wind, sea state, temperature, visibility and ice are presented. Assumptions for each condition are reported. Limitations imposed by ice for mechanical recovery operations are discussed and potential benefits are presented (e.g., use of ice leads for oil containment and recovery with skimmers).</p> <p>Dispersant application was discussed for vessel and aircraft application and limitations were presented. Aircraft operation utilizing helicopters was favored over fixed wing aircraft due to increased maneuverability in ice conditions. Limitations to aircraft operation were discussed not only for dispersant operation but also for spotter roles and countermeasure effectiveness monitoring (in support of aircraft and vessel dispersant application). These limitations included temperature and visibility but did not specifically addressing icing issues.</p> <p>In-situ burning application with ignition from both aircraft and vessels is discussed. Generalized conditions for oil thickness, oil type, degree of weathering including emulsification are summarized.</p>
<p><i>Erik Buch</i></p>	<p>The description of response gap analysis, its results and limitations is well presented - much more strict and competent than data section. The data presentation - tables and figures – are easily read and understandable.</p> <p>A couple of places there is a reference to: “supported by literature” without real references mentioned, that is a weakness.</p>
<p><i>William Hutmacher</i></p>	<p>In Sect 5, 2nd Para, vessel dispersant stats (18% Chukchi and 20% Beaufort don’t agree with those in Sect 7, Figure 17.</p> <p>Sect 6.2 Response Limits – Table 12 says wind not used in this analysis so there is no need for the wind discussion paragraph. Further explain wind-generated effect on sea state. Explain in more detail how Green, Yellow, and Red sea state conditions determined.</p> <p>Sect 6, Table 12 – Once again, the Yellow/Red descriptions can be confusing. If Red means the response is not possible or not effective, does Yellow mean the response is effective? Perhaps Red should be described simply as Response: Not Possible (same comments for Tables 14, 15, 17, 18).</p>

	<p>Sect. 7.2 – Resp Limits – Again, Tables 14 & 15 state wind is not used in this analysis so there is no need for the wind discussion paragraph. Replace the wind & sea state paragraphs with one that discusses exactly how “Estimated Sea State based on W” Yellow & Red limits were determined.</p> <p>Table 14 – Ice – Yellow limit appears to be wrong – should it be $10 < I < 50$?</p> <p>Table 15 – Ice – Yellow limit appears to be wrong – should it be $10 < I < 90$?</p> <p>Figure 17 – Numbers don’t agree with those in Sect 7.3.2, Table 10, Figure 21, or Figure ES-1.</p> <p>Sect. 8.3 – Resp. Limits – Tables 17 & 18 state wind is not used in this analysis. Replace the wind & sea state paragraphs with one that discusses exactly how the “Estimated Sea State based on W” Green, Yellow, & Red limits were determined.</p> <p>Tables 17 & 18 – Ice Factor– Explain how Green and Red limits were determined.</p>
Paul Smith	<p>In reviewing table 12 in section 6 (Mechanical recovery), I once again found myself wondering how a wind speed recorded elsewhere would begin to impair an offshore mechanical recovery device. Earlier in section 6.2 it was stated that “Winds in excess of 20 knots begin to degrade the effectiveness of open-water recovery systems.” Yet table 12 did not use this parameter. Instead it used a much lower wind speed, presumably from a Beaufort scale, to extrapolate a limiting wave height, without any correction for mitigating factors discussed elsewhere in this review.</p>

6	<p><i>Were there any critical results or limitations not discussed or adequately addressed in Sections 5, 6, 7, and 8 of the report?</i></p>
Silje Berger	<p>See answer to question number 5.</p>
Carl Brown	<p>For dispersant application in the Arctic, the report mentions the fact that the presence of ice may dampen waves leading to reduced mixing energy needed for effective dispersion. It also mentions the possibility that vessel propellers can be used to introduce some energy into the environment to enhance dispersion. While this may be appropriate for small spills over a limited area, one questions the applicability for large spills over an extended area (i.e., would there be enough vessels available to provide the necessary energy to facilitate effective dispersion?)</p> <p>The statement about sea state and dispersant application being effective during calm water conditions during the Deepwater Horizon spill (Huber, 2014) should not be assumed to be representative of effectiveness with all oils and in all environments. The Macondo-252 oil was a light crude oil and fairly easily dispersed, especially in the warm waters of the Gulf of Mexico.</p> <p>As noted earlier, icing conditions for aircraft need to be considered in greater detail for safety reasons. Visibility is also an important consideration for aircraft operations especially in offshore environments where humidity and temperature changes can affect visibility and fog formation. While the report focused on</p>

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	<p>helicopter applications due to the enhanced maneuverability, the limitations on endurance offshore need to be examined in more detail along with the need for the associated vessel support.</p> <p>Limitations on in-situ burning with respect oil weathering, ice conditions, temperature and freezing conditions affect applicability of this response tactic. The report correctly points out that certain ice conditions can favor in-situ burning by providing natural containment for the spilled oil without the need for booming. Conversely the presence of ice can impair vessel operations and boom deployment, as well as burn residue recovery. The report identifies limitations when conducting in-situ burns in brash ice, these limitations affect the efficacy of the tactic.</p>
Erik Buch	I am surprised of the result that Vessel In-Situ Burning can be so relatively effective during winter – it must require availability of icebreakers in the area. This is not discussed in the report most likely because one of the assumptions in the work was that all relevant facilities would be in place.
William Hutmacher	None other than that described in para 5 above.
Paul Smith	<p>I must reiterate that wind speed measured elsewhere was poorly supported as a surrogate for wave height as the limiting factor for mechanical recovery. Even if it were, wave height alone does not limit skimmer effectiveness. Modal periods and steepness factors do, and they did not appear anywhere among the factors. The investigators’ choice to adopt 15 knots wind speed as the “mechanical recovery not possible” limit understated the potential availability of mechanical recovery in the summer season.</p> <p>As a separate matter, discussion of the effect of temperature on recovery effectiveness was limited to icing problems. While it may have been difficult to incorporate, the report would have benefitted greatly from acknowledging the effect of water temperature on the spilled product. It is well known how increased viscosity will affect the performance of mechanical recovery devices and pumps, as well as the effectiveness of dispersants.</p>

7	<i>Are the findings and overall interpretation of the results clearly discussed (Section 9)?</i>
Silje Berger	<p>As mentioned earlier, all tactics depend on oil characteristics and oil weathering. These are again influenced by the discussed environmental parameters. Not taking this into account, and not looking at the window of opportunity or the duration of the operational window for the different tactics, might lead to a slightly optimistic evaluation of the tactics, especially regarding application of dispersants and in-situ burning.</p> <p>Having mentioned this concern – which strictly speaking falls outside the defined scope of the study – the results are clearly discussed and the conclusions are well, based the results of the analysis.</p>

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	<p>An important point is highlighted by the authors in section 9.3 “SMART Protocols and In-situ Burn Residue Collection”. Excluding residue collection after in-situ burning from the analysis is expected to bias the results in favor of in-situ burning. Considering in-situ burning without collecting the residue may be a response option, and it is correctly addressed as a policy issue, as it is not in compliance with current guidelines for the area.</p>
<p><i>Carl Brown</i></p>	<p>As expected, the results of the study illustrate the difference in the applicability of the various response tactics in the summer and winter seasons. The majority of tactics are precluded during long, cold and dark winter conditions. In-situ burning both from vessels and aircraft ignition is the only viable tactic during the winter. In the more favorable summer months, vessel-based tactics including; dispersant application, in-situ burning and open water mechanical recovery are the most viable.</p> <p>The ability to monitor response tactics including water sampling and in-situ burn residue is discussed. The need for policy discussions is mentioned with respect to whether or not response tactics can be implemented without the activity of residue collection and monitoring.</p> <p>The graphical summary of Individual-Factor Response Gaps for the Chukchi Sea (page 62) is an excellent way to illustrate how the various environmental factors preclude the use of the various response tactics. The Cumulative Response Gaps images are particularly insightful.</p> <p>The report emphasizes the fact that the results of the study could be strengthened by having access to more continuous environmental data and better documented and quantified limits for the different response components. The lack of data is a common situation when dealing with remote locations in the Arctic. The question of who is responsible for deployment of the infrastructure needed to collect and store this essential data is one that needs to be addressed. The report also identifies the need for large-scale tests and real-world exercises in order to better quantify limits for various response system components. While this is important information to have, there may be legislative and regulatory impediments to such activities.</p>
<p><i>Erik Buch</i></p>	<p>No, I would have expected a more detailed discussion here based on the very good descriptions and discussions given in the previous sections (5, 6, 7, and 8).</p> <p>It is however important that the authors here stress that the results of the analysis represents an ideal picture based on the assumption that all gear and persons are ready at the moment of the oil spill.</p>
<p><i>William Hutmacher</i></p>	<p>Yes. In Sect 9.1, discussion of tactics not considered, e.g., subsea dispersants probably should not be here but should be in the Exec Summary or Introduction.</p> <p>In Figure 21, the Summer “Dispersants from Vessels” numbers don’t agree with Figure 17. Also, why is the tactic “Dispersants from Aircraft” not included in the Most Feasible Tactics Summer” column? It is considered feasible/possible 50% of the time.</p>

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<i>Paul Smith</i>	No. Figure 22 deserves better explanation. Presumably, the horizontal scale of the “postage stamp” plots is time-of-year. It is not clear why have the investigators chosen to disclose the individual seasonal factors in a low-resolution summary graphic, rather than present them within the discussion of the response tactic.
8	<i>Are the conclusions (Section 11) logical and appropriate based on the results? Are there any additional conclusions that could be drawn?</i>
<i>Silje Berger</i>	The conclusions are well based the results of the analysis. See also answer to question number 7.
<i>Carl Brown</i>	<p>The conclusions of the report are logical and appropriate based on the available (yet limited) environmental data and documented limits. The results provide a useful tool for response planners to evaluate their proposed spill response approach and selection of response tactics depending on the season and existing environmental conditions.</p> <p>Differences in response tactics between summer and winter seasons are significant, with on-water vessel activities being favored in the summer and limited options being available in the winter seasons. The presence of sea ice significantly affects the applicability of certain response tactics. It is this environmental condition that is the major difference for Arctic oil spill response relative to response in more temperate environments.</p>
<i>Erik Buch</i>	<p>Section 11 is more or less empty and do not provide any additional value.</p> <p>I will suggest that sections 9, 10, and 11 are combined into one section called conclusions and then give a more comprehensive discussion of the results and the conclusions made during this analysis.</p> <p>It would also be of value to have a paragraph on future developments needed to make this valuable tool more useful and reliable in the future.</p>
<i>William Hutmacher</i>	<p>Recommend that words be added to state that planning for an oil spill response in the Arctic will continue to be guided by federal & state regulatory requirements. This information will be helpful as regulators and regulated entities decide on appropriate, practical oil spill response plans.</p> <p>Last paragraph seems incomplete. Probably need to add words to the effect that planning the appropriate tactics for the spring transition time will be much different than for the fall transition time.</p>
<i>Paul Smith</i>	The very last paragraph of the report may be the first time the speed with which seasonal change (transition) occurs is different and says things degrade very quickly in the fall. I fail to see the value in this conclusion as presented. Yes, winter comes quickly. If this is a significant finding, incorporating longer durations than one hour in the analytical process, as noted elsewhere herein, may help illustrate the point.

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9	<i>Does this report present sufficient new data and knowledge, and are the findings useful for informing oil spill response planning?</i>
Silje Berger	<p>The report provides a good impression of environmental limitations to the regarded response tactics. The method is applicable to visualize seasonal variation and relative differences between the different tactics. Looking into more specific details in response planning, the environmental data basis might become a constraint, due to the lack of offshore measurements.</p> <p>The report serves as one piece of the big picture for contingency planning, and, of course, also other considerations must be taken into account as well. I am not very familiar with the study area, but based on the environmental data I would assume great differences in activity throughout the year, and consequently also differences in the risk of spills. Another important consideration when choosing between different tactics and putting together a “toolkit”, is what the response is aiming to protect. Finally, the feasibility of the logistics in remote locations is another important prerequisite for a successful preparation to mitigate an oil spill.</p> <p>I am convinced that not only the BSEE will find the report informative; it will also be interesting for other readers in research and spill planning.</p>
Carl Brown	<p>The report does summarize the available data in a format that helps to identify the most appropriate response tactics to use in specific seasons and discusses the limitations that are associated with each tactic. The findings are easy to understand and are useful for informing spill response planning. As with any major oil spill, readers of the report should be reminded of the need to take into account the specifics of the spill including; oil type, environmental conditions, knowledge of environmental sensitivities, and the availability of infrastructure, resources and trained personnel.</p>
Erik Buch	<p>I can only repeat what I wrote under General remarks in the beginning:</p> <p><i>“The Response Gap Analysis carried out in this report is very interesting, because it gives a clear indication of limitation that exists for oil combatting in the harsh environment of the Arctic Ocean and therefore it serves as a good tool for decision makers responsible for planning and executing oil combatting. The results are also of importance to the ongoing debate on the relevance and feasibility of exploring and extracting oil in the Arctic region and gives relevant information for planning and defining security measures for such activities.”</i></p> <p>It is however important to find better sources of relevant data because the present analysis is based on a rather poor data basis. The best will of course be to use in-situ observations with the needed geographical relevance, time and space resolution. This however can be difficult to accomplish in the Arctic region, for which reason good model data will be a good alternative.</p>
William Hutmacher	<p>The specific way the data has been organized into a specific response gap analysis is new for the Arctic. However, the environmental data sets identified have certainly been known to regulators and facility, vessel, aircraft operators as potential</p>

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	<p>operational limiting factors during spill response. The report's findings will be useful in helping oil spill response planners decide where it might make sense to put resources to most effective use during the summer and winter seasons. However, since federal and state regulatory requirements actually determine what operators must do to plan for spill response in the Arctic, it will depend on how much credence regulators give the response gap analysis findings.</p>
<i>Paul Smith</i>	<p>Let us parse this into three very different questions:</p> <ol style="list-style-type: none">1. Does this report present sufficient new data? No, it does not.2. Does this report present sufficient new knowledge? Yes, but only to the degree that it is an excellent first attempt to quantify the environmental impediments to spill response in the arctic.3. Does this report present useful findings for informing oil spill response planning? Yes. It provides another qualitative tool to skilled, experienced spill planners. It should not be used in the planning process as a quantitative tool, until it is revisited with more plentiful and pertinent data and more rigorous analysis.

4.3 Specific Observations

<i>Specific Observations</i>	
<i>Silje Berger</i>	<p>In the peer review charge document paragraph 1.1 “project history and objectives” it refers to the analysis covering three areas. The report refers to two areas. I suppose this mismatch is due to a mistake in writing.</p> <p>Page 6, 1. Introduction, line 3-5: “The response gap...” I am not a native English speaker, but something seems odd with the sentence. The meaning, though, is perfectly clear.</p>
<i>Carl Brown</i>	<p>In addition to specific observations noted above, please note the following;</p> <ul style="list-style-type: none"> ▪ Reference for Living Oceans Society, 2011, in the last line of page 6 is not included in the list of references. ▪ Reference to Alyeska’s Ship/Escort and Response Vessel System (SERVS) on page 9, is not listed in the list of references. ▪ Reference for Potter et al., 2012, in paragraph 1 on pages 10, 37, 46 and several other locations, is not included in the list of references. ▪ Reference to Farmwald and Nelson, 1982 in the last paragraph on page 43, is not included in the list of references. ▪ Reference - ARPEL Emergency Response Planning Working Group. (2007) is not cited in the text of the report. ▪ Reference - National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling. (2011 updated) is not cited in the text of the report. ▪ Reference - Naval Postgraduate School. (2006) is not cited in the text of the report. ▪ Reference - National Research Council. (1989) is not cited in the text of the report. ▪ There are two references to Nuka Research, 2007 and 2007a, which is which in the reference section? <p>Section 10 discusses assumptions related to offshore waves and the effect on results. The report determined the correlation between onshore wind speeds and median wave heights for the limited months for which actual buoy offshore data were available in the Chukchi Sea. It appears that this approach would yield lower RGIs than the actual marine data would have for this limited time period, i.e. the response would be even less likely to be possible than the report estimates.</p>
<i>Erik Buch</i>	No specific observation provided.
<i>William Hutmacher</i>	Executive Summary

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	<ul style="list-style-type: none">▪ 1st para – 3rd sentence – description of response gap analysis is different than that given in Section 1 Intro.▪ 2nd para – last sentence – remove “a” between “that” and “three”▪ Figure ES-1 – What does most “Most Feasible” mean? If it means 50% of the time, then why Dispersants from Aircraft is not included (50% Green/50% Red)? Summer “Dispersants from Vessels” figures do not agree with those in Figure 17.▪ Other Sections comments in II above.
<i>Paul Smith</i>	No specific observation provided.

5. APPENDIX A: INDIVIDUAL REVIEWER COMMENTS

5.1 Silje Berger

Peer Review of the Report “ <i>Estimating an Oil Spill Response Gap for the U.S. Arctic Ocean</i> ”	
NAME:	Silje Berger
AFFILIATION:	Norwegian Coastal Administration
DATE:	31 MAR 2015
I. 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:	<p>The report “<i>Estimating an Oil Spill Response Gap for the US Arctic Ocean</i>” provides an overall impression of the environmental conditions which might enable or preclude different response tactics in the study area, based on historic records of environmental conditions. It takes a schematic approach to compare the limitations to three different response tactics. It also visualizes substantial differences throughout the year.</p> <p>The report is well written and the information should be easy accessible to stakeholders and other audience with some experience in the field. Graphical presentation contributes well to the understanding of the results.</p> <p>The environmental data from the study area are relatively scarce, but the discussion of the limitations in the data basis, provides the reader with an understanding of which precautions should be taken in the use of the results. Furthermore, the report addresses and discusses the most important shortcomings of the methods, adding to the readers understanding of what may be extracted from the report, and what better not be derived from the results.</p> <p>My main concerns regarding the method are that oil characteristics and weathering, window of opportunity and duration of the operational window for the different tactics is not taken into account. Efficiency of the different tactics is not only influenced by the environmental conditions directly, but the environment also impacts on the oil and oil weathering. This may also be crucial for the effectiveness of the different tactics.</p> <p>All in all, the report serves as an interesting piece of the big picture for contingency planning for the area. The report provides a good impression of environmental limitations to the regarded response tactics. The method is adequate to visualize seasonal variation and relative differences between the different tactics.</p>
II. RESPONSE TO CHARGE QUESTIONS	
Provide narrative responses to each of the nine charge questions below.	
1	<i>Are the objectives of the report clearly defined? If not, what are your recommendations for improving the description of objectives?</i>
Comments:	The objectives of the study are mainly outlined in the introduction, and further specified in paragraph 2.1 “Scope of this Analysis.”

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	<p>As far as I am concerned, it is brought clearly to the point in the first paragraph, stating that the response gap analysis estimates how often a particular response tactic is likely to be precluded based on historic environmental conditions.</p> <p>For an outside reader it would be informative to have some short background information about the context of the study and the study area, like for instance:</p> <ul style="list-style-type: none"> ▪ What are the possible sources of oil spills (drilling activities, pipelines, shipping routes, etc)? ▪ Is the study related to the planning of specific activities? ▪ What are the environmental resources at risk? <p>The BSEE surely is very well aware of the context, so this would apply for other readers who might use the results of the report (e.g., external researchers, companies that take the analysis into account in their planning, international audience).</p>
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2	<p><i>Was the methodology (Section 2) used for the responses gap analysis appropriately designed and clearly described? Were there any apparent weaknesses or gaps with the approach used to develop the environmental limits and estimate the Response Gap Index (RGI)?</i></p>
Comments:	<p>Developing environmental limits for the different tactics is a difficult task due to limited documentation. It is difficult to verify these limits, amongst others for the reasons mentioned in section 2.5. There are also different approaches to evaluate the efficiency from experience (past spills), and documentation – if available at all – leaves room for different interpretations. The approach to review literature and subsequently vet the findings with experts seems to be the best achievable approach. However, environmental limitations will inevitably remain subject to discussion among experts, analysts, responders as well as equipment manufacturers.</p> <p>The methodology is explained in generally well understandable terms. Description of the program could be more extensive, i.e., by adding a reference to a closer description of how the calculation is performed, if this is published somewhere else. From this description I assume that it is based on a simple cut-off when the limit value is exceeded.</p>

3	<p><i>Are the limitations of the approach (Section 2.5) clearly identified and described?</i></p>
Comments:	<p>Section 2.5 highlights limitations to the approach in a clear and understandable way.</p> <p>A simplified incorporation of response degradation is mentioned, and I want to highlight this point, because it is important to understand the consequence of this simplification. The transition from effective to not effective is not very well resolved in this approach. A simple yes or no answer is often desirable to stakeholders; however, a yes/no answer do not entirely reflect the complexity of environmental limitations to different tactics.</p>

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	An apparent weakness is that oil characteristics and weathering of the oil is not taken into account. Efficiency of the different tactics is not only influenced by the environmental conditions directly, but the environment also impacts on the oil and oil weathering. This may also be crucial for the effectiveness of the different tactics. For instance do temperature and sea state influence on the viscosity of an oil slick, and hence on the applicability of a certain tactic, like the efficiency of dispersants.
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4	<i>Were the environmental data sources used for the response gap analysis clearly described and adequately characterized (Sections 3 and 4)? Is there any other publically available data that should have been considered?</i>
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Comments:	<p>Section 4 and 5 as well as the appendices describe the environmental data used in the study in clear terms. The report also addresses the very limited access to offshore measurements and the resulting uncertainties. Improved offshore data would certainly add to the report’s soundness, but the report provides the overall picture of operational challenges of an oil spill response in the area.</p> <p>The arguments for using one-hour increments of the environmental input data in the analysis are not described in much detail. It is not obvious why hourly increments are more applicable than for instance daily increments, especially taking into account that the discussion focuses on the larger picture of summer versus winter conditions. Furthermore, it is emphasized by the authors themselves in section 2.5 that they do not consider if there are enough consecutive time increments to apply the different tactics. As far as I am concerned, the reason for this approach does not lie in the environmental data themselves and the data would support a modified approach addressing this as well.</p>
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5	<i>Were the results of the response gap analysis (Sections 5, 6, 7, 8) for each tactic (i.e., open-water mechanical recovery, application of dispersants, and in-situ burning) appropriate and clearly described? Was the RGI and associated graphical outputs clearly presented?</i>
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Comments:	<p>The results are generally well described and the graphical presentation is very informative to the reader.</p> <p><u>Open-water mechanical recovery</u>: Modified tactics of mechanical recovery are describe in section 6.1 “overview of tactic,” but not included in the analysis.</p> <p>It is noted, that the limits of mechanical recovery are better described in the literature, this may also reflect that there is more experience with this tactic, and hence the limits has been explored to a greater extent, both in research, but particularly resulting from experience from past spills.</p> <p><u>Application of dispersants</u>: The limits for sea state and wind have no minimum value, and the authors present a reasonable argumentation for this assumption. However, if it is necessary to add mixing energy, it is likely that this will slow the response and hence lead to reduced overall efficiency of the tactic. This is noted as a general comment. This is particularly relevant during transitional ice conditions,</p>
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	<p>which is present only short periods of the year in the study area, so this is probably not of great significance in this study.</p> <p>As mentioned in section 7.2 “Response Limits” water temperature, pH and salinity may affect the effectiveness of dispersants, but not their application. This exemplifies that the fact that a tactic is possible to apply, does not necessarily mean that it is effective. Furthermore, it is neither necessarily so that it causes the least environmental damage (often referred to as net environmental benefit).</p> <p><u>In-situ burning</u>: One of the major drawbacks with the tactic in-situ burning may be a short window of opportunity. As oil characteristics are not included in the analysis this is not taken into account, but it might be an important issue for contingency planning.</p> <p><u>Some additional considerations based on my experience</u>:</p> <ul style="list-style-type: none"> ▪ The limitations due to visibility might to some extent be overcome by technology enabling effective vessel operations in low visibility conditions, such as infrared cameras and oil detection radar. ▪ There is some (although limited) experience of successful mechanical recovery operations in darkness as well as dispersant application in darkness from Norway. ▪ During the response operations after the grounding of the vessel MV Godafoss in Norwegian waters in 2011 effective mechanical recovery operations were run in darkness (during nighttime) using detection equipment on board a Norwegian Coast Guard vessel to target the oil. The weather during this response was characterized by temperatures between -10 and -20 °C, but almost no wind and a calm sea state. On the other hand, already low ice concentrations turned out to reduce effectiveness of mechanical recovery substantially in some locations, in other locations the ice acted as a barrier to the oil. The consistence and characteristics of the ice determined how it affected the recovery operation. ▪ Dispersant application in darkness took place after an oil spill at “Draugen”-oilfield in the Norwegian Sea in 2006. Dispersants were applied from a vessel equipped with spraying booms, with aerial guidance by a surveillance aircraft. Aerial guidance was crucial for the correct application of the dispersant.
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6	<i>Were there any critical results or limitations not discussed or adequately addressed in Sections 5, 6, 7, and 8 of the report?</i>
Comments:	See answer to question number 5.

7	<i>Are the findings and overall interpretation of the results clearly discussed (Section 9)?</i>
Comments:	As mentioned earlier, all tactics depend on oil characteristics and oil weathering. These are again influenced by the discussed environmental parameters. Not taking

	<p>this into account, and not looking at the window of opportunity or the duration of the operational window for the different tactics, might lead to a slightly optimistic evaluation of the tactics, especially regarding application of dispersants and in-situ burning.</p> <p>Having mentioned this concern – which strictly speaking falls outside the defined scope of the study – the results are clearly discussed and the conclusions are well, based the results of the analysis.</p> <p>An important point is highlighted by the authors in section 9.3 “SMART Protocols and In-situ Burn Residue Collection”. Excluding residue collection after in-situ burning from the analysis is expected to bias the results in favor of in-situ burning. Considering in-situ burning without collecting the residue may be a response option, and it is correctly addressed as a policy issue, as it is not in compliance with current guidelines for the area.</p>
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8	<i>Are the conclusions (Section 11) logical and appropriate based on the results? Are there any additional conclusions that could be drawn?</i>
Comments:	The conclusions are well based the results of the analysis. See also answer to question number 7.

9	<i>Does this report present sufficient new data and knowledge, and are the findings useful for informing oil spill response planning?</i>
Comments:	<p>The report provides a good impression of environmental limitations to the regarded response tactics. The method is applicable to visualize seasonal variation and relative differences between the different tactics. Looking into more specific details in response planning, the environmental data basis might become a constraint, due to the lack of offshore measurements.</p> <p>The report serves as one piece of the big picture for contingency planning, and, of course, also other considerations must be taken into account as well. I am not very familiar with the study area, but based on the environmental data I would assume great differences in activity throughout the year, and consequently also differences in the risk of spills. Another important consideration when choosing between different tactics and putting together a “toolkit”, is what the response is aiming to protect. Finally, the feasibility of the logistics in remote locations is another important prerequisite for a successful preparation to mitigate an oil spill.</p> <p>I am convinced that not only the BSEE will find the report informative; it will also be interesting for other readers in research and spill planning.</p>

III. SPECIFIC OBSERVATIONS	
Provide specific observations or comments on the report mentioning page and paragraph (expand table if needed).	
Comments:	In the peer review charge document paragraph 1.1 “project history and objectives” it

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refers to the analysis covering three areas. The report refers to two areas. I suppose this mismatch is due to a mistake in writing.

Page 6, 1. Introduction, line 3-5: “The response gap...” I am not a native English speaker, but something seems odd with the sentence. The meaning, though, is perfectly clear.

5.2 Carl Brown

Peer Review of the Report “Estimating an Oil Spill Response Gap for the U.S. Arctic Ocean”

NAME:	Carl Brown
AFFILIATION:	Environment Canada
DATE:	30 MAR 2015

I. 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 does a good job in estimating the oil spill response gap for the U.S. Arctic Ocean, specifically for the Chukchi and Beaufort Sea areas. The report clearly identifies the objective of estimating how often a specific response tactic would be precluded based on environmental conditions.

It is clear that the authors have examined a large number of data sets and consulted with relevant subject matter experts and organizations.

The methodology used in the study is based largely on earlier studies done by the same authors in nearby geographic locations with some modifications and developments. The report identifies the available environmental data and the limits imposed by a lack of data and data quality in some cases. Environmental data shortfalls are not an uncommon circumstance in remote Arctic locations. The report carefully identifies and explains all of the assumptions that are made with respect to the available data and which environmental conditions are or not included in the analysis. Not all possible response tactics are included in the evaluation and those which are not are clearly identified. The response gap does not estimate the extent to which the response tactic would be effective, nor does it discuss how the type of oil or environmental weathering might reduce response effectiveness. The time required to operationalize response assets and transit to the spill location are not considered in the study.

The textual and graphical representations of the results of the study facilitate the rapid understanding of which response tactics are appropriate and under which conditions during the summer and winter seasons.

The conclusions of the report are logical and appropriate based on the available environmental data and documented limits. The results provide a useful tool for response planners to evaluate their proposed spill response approach and selection of response tactics depending on the season and existing environmental conditions.

Differences in response tactics between summer and winter seasons are significant, with on-water vessel activities being favored in the summer and limited options being available in the winter seasons. The presence of sea ice significantly affects the applicability of certain response tactics. It is this environmental condition that is the major difference for Arctic oil spill response relative to response in more temperate environments.

II. RESPONSE TO CHARGE QUESTIONS

Provide narrative responses to each of the nine charge questions below.

1	<i>Are the objectives of the report clearly defined? If not, what are your recommendations for improving the description of objectives?</i>
Comments:	The stated objectives are to undertake a first response gap analysis of the U.S. Arctic Ocean in order to estimate how often a particular response tactic would be precluded based strictly on historic environmental conditions. The gap analysis focuses on the impact of environmental conditions on the ability to deploy a response. The report does not consider equipment and trained personnel, assuming that the resources are available both in-region and from other locations. The report identifies the data shortfalls, and acknowledges that local conditions may be different from conditions where data are available.

2	<i>Was the methodology (Section 2) used for the responses gap analysis appropriately designed and clearly described? Were there any apparent weaknesses or gaps with the approach used to develop the environmental limits and estimate the Response Gap Index (RGI)?</i>
Comments:	<p>The methodology used was developed for earlier studies in Prince William Sound, Alaska, northern British Columbia, the Aleutian Islands and the Canadian Beaufort Sea. The most appropriate spill response tactics were identified for study and the relevant environmental factors selected. The response gaps were summarized both textually as a percentage of time during which the response tactic would be precluded (Response Gap Index, RGI) and graphically in colors (Green – response possible, or Red – response not possible or effective). When environmental conditions impact operations but do not prevent them, they are identified as Yellow. Response tactics can be precluded by one environmental condition or a combination of conditions. Two or more Yellow environmental conditions would lead to a Red RGI – response not possible or effective.</p> <p>The methodology identified the limited available data for relevant environmental conditions, establishes operational limits for environment factors based on available and professional judgment, and compared the operational limits with historic data and estimated the Response Gap Index.</p> <p>The graphical representation depicts seasonal variations and is nuanced to show shading of green and red to identify degradation of response capability. This graphical representation provides a rapid way to identify the appropriateness of a specific response tactic both seasonally (x-axis, generally better in summer) and percentage wise (y-axis).</p> <p>The methodology does have some inherent weaknesses including; limited data availability particularly for the offshore environment, it makes assumptions about equipment and personnel availability, does not provide details on the custom program used to calculate the Response Gap Index (have details of the program been published and/or peer-reviewed?) The report identifies that only complete datasets are used to calculate the RGI and graphical outputs (i.e. if one or more</p>

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	environmental conditions are missing for a given hour, the results are not included for that particular hour).
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3	<i>Are the limitations of the approach (Section 2.5) clearly identified and described?</i>
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Comments:	<p>The report does a good job of identifying limitations of the approach. The limitations are identified by acknowledging the assumptions made, for example it is assumed that the response tactic is always available during favorable environmental conditions, this would lead to an overestimation of response capability. The response gap does not estimate the extent to which the response tactic would be effective (e.g., mechanical recovery rate or in-situ burn efficiency). The approach does not consider oil type, or the effects of environmental weathering on the oil (evaporation, emulsification etc.) which could influence the effectiveness of a particular response tactic.</p> <p>The report acknowledges that in some cases the quality and availability of environmental data are limited or not available (a frequent occurrence in remote locations). In some cases, data are not available for a particular location and the analysis then relies on onshore data to estimate conditions offshore. The report acknowledges that offshore conditions might be significantly different than onshore conditions.</p> <p>The report relies on a hindcast of environmental data to inform future conditions. Given the recent rapid changes in the Arctic climate, the hindcast was based on the prior 5 years of conditions in spite of the fact that much longer data records are available. This approach assumes that environmental conditions will not revert to the historical normal (i.e., colder) in the near future.</p> <p>The report acknowledges the lack of good documentation on response limits. In addition, much of the data on oil spill response equipment performance is based on bench or test tank studies instead of real-world tests. This approach would overestimate the effectiveness of the response tactic. The report identifies the need to validate response limit assumptions. The report assumes a gradual degradation of response tactics, realizing that response efficiency does not go from 100% to 0% when environmental conditions change from a yellow to red value.</p> <p>The RGI incorporates environmental data into hourly conditions (either from direct measurements or interpolated from weekly data). It does not consider whether there are good environment conditions of sufficient duration to mobilize, deploy and demobilize response tactics. This would lead to an overestimate of response tactic capability.</p>
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4	<i>Were the environmental data sources used for the response gap analysis clearly described and adequately characterized (Sections 3 and 4)? Is there any other publically available data that should have been considered?</i>
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Comments:	As noted earlier, there is a paucity of environmental data for the offshore Chukchi and Beaufort Sea areas. Those offshore weather buoy data that are available are
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	<p>limited to short periods of time in the summer for a couple of years. Data from onshore locations (airports) are used extensively. Is it possible that anecdotal data are available from local pilots to compare IFR/VFR conditions offshore to those recorded at local airports? Sea ice coverage is from weekly charts, interpreted from satellite data by ice analysis experts. Daily ice concentrations are extrapolated from weekly data assuming a linear transition between data points for each week. Actual sea ice data are taken from only two locations approximately 270 miles apart.</p> <p>Data for onshore wind, air temperature and visibility data from onshore airport facilities are shown to be very complete over the 5 year period. This is in stark contrast to the availability of offshore buoy data which is limited to a total of 128 days during two summers. These offshore data measurements are not well documented, so data interpretation is difficult. One important observation is that there is more variability in the offshore buoy wind direction and wind speed.</p> <p>The efforts to identify sources of sea state data were extensive, with numerous experts and organizations identified. Are data available from sources such as the Canadian Ice Service, Environment Canada? Sea states were estimated using wind and ice dampening effects on waves.</p> <p>Visibility is estimated in three ways; horizontal visibility, cloud ceiling, and daylight/night at local airports. The horizontal visibility is related to airspace flight rules (visual flight rules, VFR) which require visibility of at least one mile. This provides context for possible impact on response operations. The report correctly identifies that visibility at the airport can be very different from that on the water (i.e., land mass temperatures heat/cool faster than water – affecting the dew point and fog formation). Although it is not considered in the report, it is important to recognize that significant periods of time might be needed for transit from airports to spill locations. Visibility is very important for dispersant application and monitoring, additional analysis would be beneficial.</p> <p>Aircraft icing was not included in the analysis yet this information is essential for safe and effective spill response operations. Additional study would be beneficial and would lead to more realistic estimates of times during which response tactics requiring aircraft would be precluded.</p>
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5	<p><i>Were the results of the response gap analysis (Sections 5, 6, 7, 8) for each tactic (i.e., open-water mechanical recovery, application of dispersants, and in-situ burning) appropriate and clearly described? Was the RGI and associated graphical outputs clearly presented?</i></p>
Comments:	<p>As expected, all response tactics are more likely to be feasible in summer conditions than in winter.</p> <p>Mechanical recovery is reported to be possible in open-water conditions with waves of up to 6 feet and in winds of up to 30 knots. Limitations posed by environmental conditions such as wind, sea state, temperature, visibility and ice are presented. Assumptions for each condition are reported. Limitations imposed by ice for</p>

mechanical recovery operations are discussed and potential benefits are presented (e.g., use of ice leads for oil containment and recovery with skimmers).

Dispersant application was discussed for vessel and aircraft application and limitations were presented. Aircraft operation utilizing helicopters was favored over fixed wing aircraft due to increased maneuverability in ice conditions. Limitations to aircraft operation were discussed not only for dispersant operation but also for spotter roles and countermeasure effectiveness monitoring (in support of aircraft and vessel dispersant application). These limitations included temperature and visibility but did not specifically addressing icing issues.

In-situ burning application with ignition from both aircraft and vessels is discussed. Generalized conditions for oil thickness, oil type, degree of weathering including emulsification are summarized.

6 *Were there any critical results or limitations not discussed or adequately addressed in Sections 5, 6, 7, and 8 of the report?*

Comments: For dispersant application in the Arctic, the report mentions the fact that the presence of ice may dampen waves leading to reduced mixing energy needed for effective dispersion. It also mentions the possibility that vessel propellers can be used to introduce some energy into the environment to enhance dispersion. While this may be appropriate for small spills over a limited area, one questions the applicability for large spills over an extended area (i.e., would there be enough vessels available to provide the necessary energy to facilitate effective dispersion?)

The statement about sea state and dispersant application being effective during calm water conditions during the Deepwater Horizon spill (Huber, 2014) should not be assumed to be representative of effectiveness with all oils and in all environments. The Macondo-252 oil was a light crude oil and fairly easily dispersed, especially in the warm waters of the Gulf of Mexico.

As noted earlier, icing conditions for aircraft need to be considered in greater detail for safety reasons. Visibility is also an important consideration for aircraft operations especially in offshore environments where humidity and temperature changes can affect visibility and fog formation. While the report focused on helicopter applications due to the enhanced maneuverability, the limitations on endurance offshore need to be examined in more detail along with the need for the associated vessel support.

Limitations on in-situ burning with respect oil weathering, ice conditions, temperature and freezing conditions affect applicability of this response tactic. The report correctly points out that certain ice conditions can favor in-situ burning by providing natural containment for the spilled oil without the need for booming. Conversely the presence of ice can impair vessel operations and boom deployment, as well as burn residue recovery. The report identifies limitations when conducting in-situ burns in brash ice, these limitations affect the efficacy of the tactic.

7	<i>Are the findings and overall interpretation of the results clearly discussed (Section 9)?</i>
Comments:	<p>As expected, the results of the study illustrate the difference in the applicability of the various response tactics in the summer and winter seasons. The majority of tactics are precluded during long, cold and dark winter conditions. In-situ burning both from vessels and aircraft ignition is the only viable tactic during the winter. In the more favorable summer months, vessel-based tactics including; dispersant application, in-situ burning and open water mechanical recovery are the most viable.</p> <p>The ability to monitor response tactics including water sampling and in-situ burn residue is discussed. The need for policy discussions is mentioned with respect to whether or not response tactics can be implemented without the activity of residue collection and monitoring.</p> <p>The graphical summary of Individual-Factor Response Gaps for the Chukchi Sea (page 62) is an excellent way to illustrate how the various environmental factors preclude the use of the various response tactics. The Cumulative Response Gaps images are particularly insightful.</p> <p>The report emphasizes the fact that the results of the study could be strengthened by having access to more continuous environmental data and better documented and quantified limits for the different response components. The lack of data is a common situation when dealing with remote locations in the Arctic. The question of who is responsible for deployment of the infrastructure needed to collect and store this essential data is one that needs to be addressed. The report also identifies the need for large-scale tests and real-world exercises in order to better quantify limits for various response system components. While this is important information to have, there may be legislative and regulatory impediments to such activities.</p>
8	<i>Are the conclusions (Section 11) logical and appropriate based on the results? Are there any additional conclusions that could be drawn?</i>
Comments:	<p>The conclusions of the report are logical and appropriate based on the available (yet limited) environmental data and documented limits. The results provide a useful tool for response planners to evaluate their proposed spill response approach and selection of response tactics depending on the season and existing environmental conditions.</p> <p>Differences in response tactics between summer and winter seasons are significant, with on-water vessel activities being favored in the summer and limited options being available in the winter seasons. The presence of sea ice significantly affects the applicability of certain response tactics. It is this environmental condition that is the major difference for Arctic oil spill response relative to response in more temperate environments.</p>
9	<i>Does this report present sufficient new data and knowledge, and are the findings</i>

	<i>useful for informing oil spill response planning?</i>
Comments:	The report does summarize the available data in a format that helps to identify the most appropriate response tactics to use in specific seasons and discusses the limitations that are associated with each tactic. The findings are easy to understand and are useful for informing spill response planning. As with any major oil spill, readers of the report should be reminded of the need to take into account the specifics of the spill including; oil type, environmental conditions, knowledge of environmental sensitivities, and the availability of infrastructure, resources and trained personnel.

III. SPECIFIC OBSERVATIONS	
Provide specific observations or comments on the report mentioning page and paragraph (expand table if needed).	
Comments:	<p>In addition to specific observations noted above, please note the following;</p> <ul style="list-style-type: none"> ▪ Reference for Living Oceans Society, 2011, in the last line of page 6 is not included in the list of references. ▪ Reference to Alyeska’s Ship/Escort and Response Vessel System (SERVS) on page 9, is not listed in the list of references. ▪ Reference for Potter et al., 2012, in paragraph 1 on pages 10, 37, 46 and several other locations, is not included in the list of references. ▪ Reference to Farmwald and Nelson, 1982 in the last paragraph on page 43, is not included in the list of references. ▪ Reference - ARPEL Emergency Response Planning Working Group. (2007) is not cited in the text of the report. ▪ Reference - National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling. (2011 updated) is not cited in the text of the report. ▪ Reference - Naval Postgraduate School. (2006) is not cited in the text of the report. ▪ Reference - National Research Council. (1989) is not cited in the text of the report. ▪ There are two references to Nuka Research, 2007 and 2007a, which is which in the reference section? <p>Section 10 discusses assumptions related to offshore waves and the effect on results. The report determined the correlation between onshore wind speeds and median wave heights for the limited months for which actual buoy offshore data were available in the Chukchi Sea. It appears that this approach would yield lower RGIs than the actual marine data would have for this limited time period, i.e., the response would be even less likely to be possible than the report estimates.</p>

5.3 Erik Buch

Peer Review of the Report “Estimating an Oil Spill Response Gap for the U.S. Arctic Ocean”

NAME:	Erik Buch
AFFILIATION:	Buch Ocean
DATE:	18 MAR 2015

I. 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 Response Gap Analysis carried out in this report is very interesting, because it gives a clear indication of limitation that exists for oil combatting in the harsh environment of the Arctic Ocean and therefore it serves as a good tool for decision makers responsible for planning and executing oil combatting. The results are also of importance to the ongoing debate on the relevance and feasibility of exploring and extracting oil in the Arctic region and gives relevant information for planning and defining security measures for such activities.

The quality of the analysis is however not better than the data used for the analysis. It is a well-known fact that meteorological and oceanographic observations are sparse in the Arctic Region. This is also displayed clearly in this report where there hardly exists any relevant data from the ocean areas in question. I am therefore surprised that the authors have not used model outputs instead. The benefit of using model re-analysis data would have been:

- Long time series of all relevant meteorological and oceanographic parameters from the offshore areas;
- The analysis could have covered several locations in the two sea areas to investigate regional differences;
- It could have opened the possibility to include ocean currents in the analysis. The current itself will not be a limiting factor but oceans currents are important to the drift of ice and oil and therefore play a role.

The quality of the models off course is an issue i.e., how uncertain are the model output? However, most operational meteorological and oceanographic models have been well validated meaning that there quality stamps on the model output; but again this validation is not better than the available observation which –as mentioned above – are limited in the Arctic region. Nevertheless, observational data also have a quality issue depending on instrumentation, calibration periodicity etc., and this is not discussed in the report. It therefore is my belief that the analysis would have benefited from using model data as a supplement to observations.

The analysis and discussion of the various combatting methods and their limitations to environmental conditions are detailed and takes many practicalities into account and the results are very interesting and uncertainties discussed in a proper manner. It is also very good that the author underline that the result are achieved under the assumption that all practical arrangements (ships, airplanes, helicopter, gear, people

	etc) are ready and available – which probably never will be the case. So therefore the results presented in the report are ideal.
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II. RESPONSE TO CHARGE QUESTIONS

Provide narrative responses to each of the nine charge questions below.

1	<i>Are the objectives of the report clearly defined? If not, what are your recommendations for improving the description of objectives?</i>
Comments:	The objective is not clearly expressed in on paragraph at the beginning of the report – which could have been desirable. However, after having read Chapter 1 and 2 one is not in doubt on what the purpose of the exercise is.

2	<i>Was the methodology (Section 2) used for the responses gap analysis appropriately designed and clearly described? Were there any apparent weaknesses or gaps with the approach used to develop the environmental limits and estimate the Response Gap Index (RGI)?</i>
Comments:	<p>The concept and methodology behind RGI is well described – the section would benefit from a tightening up – there are some repetitions. Specific comments to section 2:</p> <ul style="list-style-type: none"> ▪ Use of model data as described above. ▪ Cannot understand why the authors restrict themselves to a 5 year period when there is available meteorological data for a much longer period. Could have opened up for a analysis of changes over time and especially to show and document if climate change have any effect on this particular subject. Now we are left with a statement on climate change but no idea if it affects the RGI and how much. ▪ Section 2.3 is not very concrete only references to other publications – it would have been good with a description on the methods and research behind the used limits.

3	<i>Are the limitations of the approach (Section 2.5) clearly identified and described?</i>
Comments:	The limitations are generally clearly identified and described; I do however disagree with some of the choices made as mentioned above.

4	<i>Were the environmental data sources used for the response gap analysis clearly described and adequately characterized (Sections 3 and 4)? Is there any other publically available data that should have been considered?</i>
Comments:	<p>The data and the data sources are well described (several times). I have the following specific comments:</p> <ul style="list-style-type: none"> ▪ I find it hard to believe that there do not exists more detailed metadata (position, time of operation, instruments etc.) on the data buoys neither at the data

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	<p>originators nor at NODC.</p> <ul style="list-style-type: none"> ▪ I would suspect that there exist some cruise data from research vessels from the two sea areas from the 5 year period used in this analysis, maybe also data from moorings. ▪ Ice concentrations are based on two selected points: <ul style="list-style-type: none"> ○ On what basis are they selected? ○ I think it would have been better to use ice concentration in an area, since both oil and ice is drifting driven by wind and ocean currents. ▪ Satellite remote sensing data on SST and sea ice exists and could have supplemented the data used. ▪ It would have been desirable with a discussion on the quality of the data used. ▪ In the presentation and discussion of data (Cap.4) it is relatively uninteresting to see presentation of monthly mean values based on the 5 years when the subsequent RGI analysis uses hourly values. It would have been more interesting to have a display of real values.
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5	<p><i>Were the results of the response gap analysis (Sections 5, 6, 7, 8) for each tactic (i.e., open-water mechanical recovery, application of dispersants, and in-situ burning) appropriate and clearly described? Was the RGI and associated graphical outputs clearly presented?</i></p>
Comments:	<p>The description of response gap analysis, its results and limitations is well presented - much more strict and competent than data section. The data presentation - tables and figures – are easily read and understandable.</p> <p>A couple of places there is a reference to: “supported by literature” without real references mentioned, that is a weakness.</p>

6	<p><i>Were there any critical results or limitations not discussed or adequately addressed in Sections 5, 6, 7, and 8 of the report?</i></p>
Comments:	<p>I am surprised of the result that Vessel In-Situ Burning can be so relatively effective during winter – it must require availability of icebreakers in the area. This is not discussed in the report most likely because one of the assumptions in the work was that all relevant facilities would be in place.</p>

7	<p><i>Are the findings and overall interpretation of the results clearly discussed (Section 9)?</i></p>
Comments:	<p>No, I would have expected a more detailed discussion here based on the very good descriptions and discussions given in the previous sections (5, 6, 7, and 8).</p>

	It is however important that the authors here stress that the results of the analysis represents an ideal picture based on the assumption that all gear and persons are ready at the moment of the oil spill.
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8	<i>Are the conclusions (Section 11) logical and appropriate based on the results? Are there any additional conclusions that could be drawn?</i>
Comments:	<p>Section 11 is more or less empty and do not provide any additional value.</p> <p>I will suggest that sections 9, 10, and 11 are combined into one section called conclusions and then give a more comprehensive discussion of the results and the conclusions made during this analysis.</p> <p>It would also be of value to have a paragraph on future developments needed to make this valuable tool more useful and reliable in the future.</p>

9	<i>Does this report present sufficient new data and knowledge, and are the findings useful for informing oil spill response planning?</i>
Comments:	<p>I can only repeat was I wrote under General remarks in the beginning:</p> <p><i>“The Response Gap Analysis carried out in this report is very interesting, because it gives a clear indication of limitation that exists for oil combatting in the harsh environment of the Arctic Ocean and therefore it serves as a good tool for decision makers responsible for planning and executing oil combatting. The results are also of importance to the ongoing debate on the relevance and feasibility of exploring and extracting oil in the Arctic region and gives relevant information for planning and defining security measures for such activities.”</i></p> <p>It is however important to find better sources of relevant data because the present analysis is based on a rather poor data basis. The best will off course be to use in-situ observations with the needed geographical relevance, time and space resolution. This however can be difficult to accomplish in the Arctic region, for which reason good model data will be a good alternative.</p>

III. SPECIFIC OBSERVATIONS	
Provide specific observations or comments on the report mentioning page and paragraph (expand table if needed).	
Comments:	No specific observation was provided.

5.4 William Hutmacher

Peer Review of the Report “Estimating an Oil Spill Response Gap for the U.S. Arctic Ocean”

NAME:	William Hutmacher
AFFILIATION:	None
DATE:	9 MAR 2015

I. 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:	<p>The report should be a helpful tool that spill response planners may use to help determine which spill response tactics and their associated resources may be most effective during the summer and winter seasons in the Arctic. However, the actual planning to choose tactics will still have to be in accordance with the current federal and state regulations. The environmental limitations regarding specific spill response tactics are mostly known but have not been compiled in a response gap analysis for the Arctic like this before. The type of spill response tactic used in the analysis was limited in number but the reasoning for this limitation was not discussed at all. Was this limitation prescribed by BSEE? Terminology in the report regarding tactic “effectiveness” was not clear. Terms such as “ineffective,” “impossible,” “possible,” “feasible,” “not possible,” “not feasible,” “most feasible,” “impaired,” “precluded” need to be defined, explained, or replaced. How the response gap index is applied (Table 1) in determining “most feasible,” “impaired,” “impossible,” “precluded” tactics is not explained satisfactorily. It seems to be an arbitrary approach that suggests elimination of a response tactic during a specific season when it may actually be somewhat effective.</p>
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II. RESPONSE TO CHARGE QUESTIONS

Provide narrative responses to each of the nine charge questions below.

1	<p><i>Are the objectives of the report clearly defined? If not, what are your recommendations for improving the description of objectives?</i></p>
Comments:	<p>No. Neither the Executive Summary nor Sect 1 specifically states the objective(s) of the report. The Exec Summary and/or Sect 1 should specifically state the objective/task assigned by the BSEE. What exactly did BSEE task them to report on? For example, they could use the one in the Project History & Objectives section of the Peer Review Charge Document, i.e., BSEE contracted Nuka Research “to perform an oil spill response gap analysis for three areas in the U.S. Arctic Beaufort and Chukchi Seas.” If BSEE was more specific in its definition of oil spill response gap analysis, then that should be included also.</p>

2	<p><i>Was the methodology (Section 2) used for the responses gap analysis appropriately designed and clearly described? Were there any apparent weaknesses or gaps with the approach used to develop the environmental limits and estimate the Response Gap Index (RGI)?</i></p>
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Comments:	<p>How was the scope of the analysis determined, specifically with respect to the spill response tactics included and those not included? Why were tactics such as</p>
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	<p>underwater dispersant injection, on-ice oil removal, and under-ice oil removal not included? If the tactics selected for the study were predetermined by BSEE, then that should be stated. If not, discuss the reasoning behind the limitation of tactics studied.</p> <p>The Yellow/Red environmental conditions need additional explanation and distinction. As stated, the Yellow condition is “expected to impact the operations or their effectiveness.” What does “impact the operations or their effectiveness” mean? What is the measurement used to determine the level of impact on operations or their effectiveness?</p> <p>The Red condition “precludes deployment or response ineffective.” While “precludes deployment” is a clear measure, “response ineffective” is not. Does Red mean 100% ineffective? What is the difference between Yellow condition’s “impact...their effectiveness” and Red condition’s “response ineffective”?</p> <p>Also, in all the response limit tables (Tables 12, 14, 15, 17, 18), the Red heading says “Response: Not Possible/Effective.” The condition descriptions in Sect 2.2.2, they should probably say “Response: Precludes Deployment or Response Ineffective, or Red should say Response: Not Possible (see para 6 below).</p> <p>Table 1. Applying the Response Gap Index. This table needs further explanation in Sect 2.2.3 with respect to “If two or more factors are ruled Yellow, then the RGI is Red.” Why should two Yellow factors result in a Red classification? Yellow means that the environmental factors are “expected to impact the operations or their effectiveness,” not prevent them. This could unnecessarily limit consideration of a tactic that could have some degree of effectiveness over a greater part of the year.</p>
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3	<p><i>Are the limitations of the approach (Section 2.5) clearly identified and described?</i></p>
Comments:	<p>As noted in the paragraph 2, the Yellow/Red condition distinction and the basis for the critical Table 1 (Applying the Response Gap Index) are not explained satisfactorily. In “Simplified incorporation of response degradation,” it is noted that “response efficiency does not go from 100% to 0% as wind increases one knot from a Yellow value to a Red value.” Nor does response efficiency necessarily go from 100% to 0% when two of the factors change from Green to Yellow values. This arbitrary approach would seem to indicate that a tactic should not be included in a response at a certain time of year when it may actually be somewhat effective. This may have a negative effect on planners trying to give responders all the potential tools that might add to an effective response.</p>

4	<p><i>Were the environmental data sources used for the response gap analysis clearly described and adequately characterized (Sections 3 and 4)? Is there any other publically available data that should have been considered?</i></p>
Comments:	<p>The descriptions were clear and understandable. Not aware of other publicly available data.</p>

5	<i>Were the results of the response gap analysis (Sections 5, 6, 7, 8) for each tactic (i.e., open-water mechanical recovery, application of dispersants, and in-situ burning) appropriate and clearly described? Was the RGI and associated graphical outputs clearly presented?</i>
Comments:	<p>In Sect 5, 2nd Para, vessel dispersant stats (18% Chukchi and 20% Beaufort don't agree with those in Sect 7, Figure 17.</p> <p>Sect 6.2 Response Limits – Table 12 says wind not used in this analysis so there is no need for the wind discussion paragraph. Further explain wind-generated effect on sea state. Explain in more detail how Green, Yellow, and Red sea state conditions determined.</p> <p>Sect 6, Table 12 – Once again, the Yellow/Red descriptions can be confusing. If Red means the response is not possible or not effective, does Yellow mean the response is effective? Perhaps Red should be described simply as Response: Not Possible (same comments for Tables 14, 15, 17, 18).</p> <p>Sect. 7.2 – Response Limits – Again, Tables 14 & 15 state wind is not used in this analysis so there is no need for the wind discussion paragraph. Replace the wind & sea state paragraphs with one that discusses exactly how “Estimated Sea State based on W” Yellow & Red limits were determined.</p> <p>Table 14 – Ice – Yellow limit appears to be wrong – should it be $10 < I < 50$?</p> <p>Table 15 – Ice – Yellow limit appears to be wrong – should it be $10 < I < 90$?</p> <p>Figure 17 – Numbers don't agree with those in Sect 7.3.2, Table 10, Figure 21, or Figure ES-1.</p> <p>Sect. 8.3 – Resp. Limits – Tables 17 & 18 state wind is not used in this analysis. Replace the wind & sea state paragraphs with one that discusses exactly how the “Estimated Sea State based on W” Green, Yellow, & Red limits were determined.</p> <p>Tables 17 & 18 – Ice Factor– Explain how Green and Red limits were determined.</p>
6	<i>Were there any critical results or limitations not discussed or adequately addressed in Sections 5, 6, 7, and 8 of the report?</i>
Comments:	None other than that described in para 5 above.
7	<i>Are the findings and overall interpretation of the results clearly discussed (Section 9)?</i>
Comments:	<p>Yes. In Sect 9.1, discussion of tactics not considered, e.g., subsea dispersants probably should not be here but should be in the Exec Summary or Introduction.</p> <p>In Figure 21, the Summer “Dispersants from Vessels” numbers don't agree with Figure 17. Also, why is the tactic “Dispersants from Aircraft” not included in the</p>

	Most Feasible Tactics Summer” column? It is considered feasible/possible 50% of the time.
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8	<i>Are the conclusions (Section 11) logical and appropriate based on the results? Are there any additional conclusions that could be drawn?</i>
Comments:	<p>Recommend that words be added to state that planning for an oil spill response in the Arctic will continue to be guided by federal & state regulatory requirements. This information will be helpful as regulators and regulated entities decide on appropriate, practical oil spill response plans.</p> <p>Last paragraph seems incomplete. Probably need to add words to the effect that planning the appropriate tactics for the spring transition time will be much different than for the fall transition time.</p>

9	<i>Does this report present sufficient new data and knowledge, and are the findings useful for informing oil spill response planning?</i>
Comments:	<p>The specific way the data has been organized into a specific response gap analysis is new for the Arctic. However, the environmental data sets identified have certainly been known to regulators and facility, vessel, aircraft operators as potential operational limiting factors during spill response. The report’s findings will be useful in helping oil spill response planners decide where it might make sense to put resources to most effective use during the summer and winter seasons. However, since federal and state regulatory requirements actually determine what operators must do to plan for spill response in the Arctic, it will depend on how much credence regulators give the response gap analysis findings.</p>

III. SPECIFIC OBSERVATIONS

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

Comments:	<p>Executive Summary</p> <ul style="list-style-type: none"> ▪ 1st para – 3rd sentence – description of response gap analysis is different than that given in Section 1 Intro. ▪ 2nd para – last sentence – remove “a” between “that” and “three.” ▪ Figure ES-1 – What does most “Most Feasible” mean? If it means 50% of the time, then why Dispersants from Aircraft is not included (50% Green/50% Red)? Summer “Dispersants from Vessels” figures do not agree with those in Figure 17. ▪ Other Sections comments in II above.
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5.5 Paul Smith

Peer Review of the Report “Estimating an Oil Spill Response Gap for the U.S. Arctic Ocean”

NAME:	Paul Smith
AFFILIATION:	OceanSmith Services, LLC, Mill Creek, WA
DATE:	27 MAR 2015

I. 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:

I commend the authors for attempting to extrapolate response gap indices from such thin data. I concur in their choice of parameters that would limit response operations with one exception: the omission of temperature effect on the recoverability of spilled oil.

I do not necessarily concur in their methods of extrapolation or their choice of surrogates. The attempts to correlate airport wind data to offshore sea conditions lacked rigor. The absence of any consideration of (or even discussion of) the effect of ice cover and wind duration on sea state is disappointing. It resulted in what I believe to be an unrealistically low wind speed limit to mechanical recovery.

Their conclusions with regard to the order-of-finish of total proportion of time where the different response tactics are feasible align with my own intuition or “gut feel.” For instance, I believe that conditions suitable for dispersant application from vessels will be more prevalent than those for mechanical recovery. However, I find it difficult to believe that such conditions exist for 82% of the time in the summer. Perhaps what I perceive to be an overstatement of “availability” is a result of their choice to parse the data into one-hour increments. A suitable window of opportunity to mount any useful response operation must be longer than that – to my view, 3 hours should be the minimum.

I found some of the discussion to include tangential statements that are unsubstantiated and of little value to the objectives of the study. For instance, within Section 8, it is stated that, “A heli-torch may be used to ensure rapid ignition....” It is simply not true that heli-torches ensure rapid ignition. They are just another tool to try to establish a self-sustaining burn. There is a similar unsubstantiated statement later in the section that characterizes burn residue from “most burns.” Such self-serving commentary, possessing little relationship to the objectives of the report should be removed. Or, if left in, they should be properly supported.

II. RESPONSE TO CHARGE QUESTIONS

Provide narrative responses to each of the nine charge questions below.

1	<i>Are the objectives of the report clearly defined? If not, what are your recommendations for improving the description of objectives?</i>
<i>Comments:</i>	The objectives are clearly defined.

2	<i>Was the methodology (Section 2) used for the responses gap analysis appropriately</i>
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	<i>designed and clearly described? Were there any apparent weaknesses or gaps with the approach used to develop the environmental limits and estimate the Response Gap Index (RGI)?</i>
Comments:	While the analysis methodology was clearly defined, the environmental limits selected were not. Without reading the four references listed in section 2.3, I cannot opine as to whether they have selected the “right” ice limits. As stated elsewhere in this review, I believe that their selection of wind speed limit, particularly as it relates to mechanical recovery, is weakly supported.
3	<i>Are the limitations of the approach (Section 2.5) clearly identified and described?</i>
Comments:	They are clearly identified, but not necessarily clearly described. For instance, the quality and availability of environmental data is limited. The reader is referred to Appendix A for the explanation of how they managed to correlate onshore data to offshore conditions. Appendix A was disappointing in its ability to provide either a correlation or an explanation.
4	<i>Were the environmental data sources used for the response gap analysis clearly described and adequately characterized (Sections 3 and 4)? Is there any other publically available data that should have been considered?</i>
Comments:	<p>The data sources were clearly defined and admittedly disappointing. I do not know if additional data exists.</p> <p>Again, support for the selection of surrogate data was weak. For instance, figure 4 in section 4.1 seems to present only partial correlation between offshore wind conditions and those found at the airport sites used. Winds from the SSE on the offshore buoy wind roses are not reflected in the Barrow, Wainright, or Prudhoe wind roses. The text later refers the reader to section 10 to learn of the impact of using airport wind data to develop offshore sea state conditions. Discussion found there was not illuminating. Wind direction (and the presence of ice) would have a profound effect on the effective fetch for wind-generated waves. There was no discussion or correction attempted for this.</p>
5	<i>Were the results of the response gap analysis (Sections 5, 6, 7, 8) for each tactic (i.e., open-water mechanical recovery, application of dispersants, and in-situ burning) appropriate and clearly described? Was the RGI and associated graphical outputs clearly presented?</i>
Comments:	In reviewing table 12 in section 6 (Mechanical recovery), I once again found myself wondering how a wind speed recorded elsewhere would begin to impair an offshore mechanical recovery device. Earlier in section 6.2 it was stated that “Winds in excess of 20 knots begin to degrade the effectiveness of open-water recovery systems.” Yet table 12 did not use this parameter. Instead it used a much lower wind speed, presumably from a Beaufort scale, to extrapolate a limiting wave height, without any correction for mitigating factors discussed elsewhere in this review.

6	<i>Were there any critical results or limitations not discussed or adequately addressed in Sections 5, 6, 7, and 8 of the report?</i>
Comments:	<p>I must reiterate that wind speed measured elsewhere was poorly supported as a surrogate for wave height as the limiting factor for mechanical recovery. Even if it were, wave height alone does not limit skimmer effectiveness. Modal periods and steepness factors do, and they did not appear anywhere among the factors. The investigators' choice to adopt 15 knots wind speed as the "mechanical recovery not possible" limit understated the potential availability of mechanical recovery in the summer season.</p> <p>As a separate matter, discussion of the effect of temperature on recovery effectiveness was limited to icing problems. While it may have been difficult to incorporate, the report would have benefitted greatly from acknowledging the effect of water temperature on the spilled product. It is well known how increased viscosity will affect the performance of mechanical recovery devices and pumps, as well as the effectiveness of dispersants.</p>
7	<i>Are the findings and overall interpretation of the results clearly discussed (Section 9)?</i>
Comments:	No. Figure 22 deserves better explanation. Presumably, the horizontal scale of the "postage stamp" plots is time-of-year. It is not clear why have the investigators chosen to disclose the individual seasonal factors in a low-resolution summary graphic, rather than present them within the discussion of the response tactic.
8	<i>Are the conclusions (Section 11) logical and appropriate based on the results? Are there any additional conclusions that could be drawn?</i>
Comments:	The very last paragraph of the report may be the first time the speed with which seasonal change (transition) occurs is different and says things degrade very quickly in the fall. I fail to see the value in this conclusion as presented. Yes, winter comes quickly. If this is a significant finding, incorporating longer durations than one hour in the analytical process, as noted elsewhere herein, may help illustrate the point.
9	<i>Does this report present sufficient new data and knowledge, and are the findings useful for informing oil spill response planning?</i>
Comments:	<p>Let us parse this into three very different questions:</p> <ol style="list-style-type: none"> 1. Does this report present sufficient new data? No, it does not. 2. Does this report present sufficient new knowledge? Yes, but only to the degree that it is an excellent first attempt to quantify the environmental impediments to spill response in the arctic. 3. Does this report present useful findings for informing oil spill response planning? Yes. It provides another qualitative tool to skilled, experienced spill planners. It

	should not be used in the planning process as a quantitative tool, until it is revisited with more plentiful and pertinent data and more rigorous analysis.
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III. SPECIFIC OBSERVATIONS

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

Comments:	No specific observation was provided.
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6. APPENDIX B: PEER REVIEW MATERIALS PACKAGES

The peer review materials packages are attached separately.