

Bureau of Safety and Environmental Enforcement Comment Response Document

ORSS Project #1022 Estimating an Oil Spill Response Gap for the U.S. Arctic Ocean

This is the Bureau of Safety and Environmental Enforcement's (BSEE) Comment Response Document for BSEE's Project #1022. This document addresses the questions and concerns expressed by the External Peer Review Committee. The Peer Review Committee was tasked with evaluating the scientific merit of the research report, the appropriateness of the assumptions made, and the quality and relevance of the data. Per Silje Berger, Ph.D., Norwegian Coastal Administration, Carl E. Brown, Ph.D., Environment Canada, Erik Buch, Ph.D., Buch Ocean, Bill Hutmacher, USCG (retired), Paul S. Smith, M.S., OceanSmith Services, LLC provided their expertise in the review of this report.

The Comment Response Document addresses the following:

- BSEE's agreement or disagreement with views expressed in the Peer Review Report
- Reasons those actions satisfy key concerns stated in the Peer Review Report (if applicable)

Particular attention was given to significant comments that were not accepted for incorporation into the research product.

1. Are the objectives of the report clearly Defined? If not, what are your recommendations for improving the description of objectives?

Reviewer	Reviewer Comment	BSEE Comment Response
Berger	The objectives of the study are mainly outlined in the introduction, and further specified in paragraph 2.1 "Scope of this Analysis." 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. 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: ☐ 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? 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).	Background information added to the narrative.
Brown	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.	Noted.
Buck	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.	Objective revised.
Hutmacher	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.	Objective revised.

Smith	The objectives are clearly defined.	Noted.
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2. 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)?

<u>Reviewer</u>	<u>Comment</u>	<u>BSEE Comment Response</u>
Berger	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. 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.	Revised to further describe algorithm and methodology.
Brown	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.	Noted.
Brown	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.	Noted.
Brown	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).	Noted.
Brown	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 environmental conditions are missing for a given hour, the results are not included for that particular hour).	Added additional information on the custom program used.
Buck	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:	Noted.
Buck	☐ Use of model data as described above.	Noted.

Buck	☐ 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.	Noted. Beyond scope of current contract. Will consider follow-on project to add additional data.
Buck	☐ 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.	Beyond scope of project.
Hutmacher	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.	Focus on on-water spills was agreed at start of project (as opposed to sub-sea or sub-ice releases, or spills to the surface of the ice). Revised to better clarify the focus of the project and acknowledge that other tactics may be used.
Hutmacher	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?	Clarified language to describe most limits refer to the ability to deploy tactic and have it achieve desired purpose to any extent. This varies widely depending on the tactic and what drives the limit.
Hutmacher	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”?	Clarified language to describe most limits refer to the ability to deploy tactic and have it achieve desired purpose to any extent. This varies widely depending on the tactic and what drives the limit.
Hutmacher	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).	Revised.
Hutmacher	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.	Revised the methodology and preserve the yellow conditions so that the results will be reported as percentage of time conditions are red, yellow, or green.
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.	Noted.

3. Are the limitations of the approach (Section 2.5) clearly identified and described?		
Reviewer	Comment	BSEE Comment Response
Berger	Section 2.5 highlights limitations to the approach in a clear and understandable way. 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.	Noted.

Berger	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.	Added language to further explain that oil weathering is a key factor.
Brown	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.	Noted.
Brown	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.	Noted.
Brown	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.	BSEE is satisfied with this approach.
Brown	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.	Noted.
Brown	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.	Beyond the scope of the project.
Buck	The limitations are generally clearly identified and described; I do however disagree with some of the choices made as mentioned above.	Noted.
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.	Revised the methodology and preserved the yellow conditions so that the results will be reported as percentage of time conditions are red, yellow, or green. Defined Green as Favorable, Yellow as Marginal, and Red as Not Favorable.

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.	Added additional text to clarify.
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4. Were the environmental data sources used for the response gap analysis clearly described and adequately characterized (Sectiond 3 and 4)? Is there any other publically available data that should have been considered?		
Reviewer	Comment	BSEE Comment Response
Berger	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.	Noted.
Berger	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.	Added additional details to support use of hourly increments in the final report.
Brown	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.	Nuka considered acquiring observational data in the past from vessels and/or aircraft. In general these data have to be pulled from logs. It is worthy of consideration, but expensive and time consuming to do so, and may provide observations across a wide area.
Brown	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.	Noted.
Brown	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.	Nuka did not consult those sources listed in the comment, only sources listed in the study.

Brown	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.	Noted.
Brown	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.	Noted.
Buck	The data and the data sources are well described (several times). I have the following specific comments:	Noted.
Buck	☐ 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.	Noted.
Buck	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.	Beyond the scope of this project.
Buck	☐ Ice concentrations are based on two selected points: - o On what basis are they selected? - o 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.	Locations were selected based on lease locations and with input from BSEE at start of project.
Buck	Satellite remote sensing data on SST and sea ice exists and could have supplemented the data used.	Nuka discussed utilizing multiple sources for sea ice, but then would have to devise a way to resolve discrepancies, which adds more uncertainty to the analysis. The source Nuka used is complete and fit for the purposes of the study. Hourly observations would be preferred, but this resolution is not available from the sources mentioned.
Buck	☐ It would have been desirable with a discussion on the quality of the data used.	Added a statement on sources of data and data quality/integrity.
Buck	☐ In the presentation and discussion of data (Chapter 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.	Noted.
Hutmacher	The descriptions were clear and understandable. Not aware of other publicly available data.	Noted.
Smith	The data sources were clearly defined and admittedly disappointing. I do not know if additional data exists.	Noted.

Smith	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.	Noted.
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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?

<u>Reviewer</u>	<u>Comment</u>	<u>BSEE Comment Response</u>
Berger	The results are generally well described and the graphical presentation is very informative to the reader.	Noted.
Berger	Open-water mechanical recovery: Modified tactics of mechanical recovery are describe in section 6.1 “overview of tactic,” but not included in the analysis.	Nuka chose the tactic that was the most likely to be deployed in the region. Many alternates of most tactics exist and each could be analyzed. A sensitivity analysis can be run to look into the affects of variations, but was not part of the scope for this analysis.
Berger	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.	Noted.
Berger	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.	Noted.
Berger	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).	Beyond the scope of the project.
Berger	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.	Noted.
Berger	Some additional considerations based on my experience: overcome by technology enabling effective vessel operations in low visibility conditions, such as infrared cameras and oil detection radar.	☐ Revised section to acknowledged that emergining technologies may enhance vessel operations in the future, but until these tools are more widely used there is limited data and basis to include in this analysis.
Berger	☐ There is some (although limited) experience of successful mechanical recovery operations in darkness as well as dispersant application in darkness from Norway.	Noted.

Berger	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.	Noted.
Berger	☐ 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.	Noted.
Brown	As expected, all response tactics are more likely to be feasible in summer conditions than in winter.	Noted.
Brown	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).	Noted.
Brown	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.	Noted.
Brown	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.	Noted.
Buck	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.	Noted.
Buck	A couple of places there is a reference to: "supported by literature" without real references mentioned, that is a weakness.	Revised accordingly.
Hutmacher	In Sect 5, 2nd Para, vessel dispersant stats (18% Chukchi and 20% Beaufort don't agree with those in Sect 7, Figure 17.	Revised accordingly.
Hutmacher	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.	Revised accordingly.
Hutmacher	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).	Revised accordingly.
Hutmacher	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.	Revised accordingly.
Hutmacher	Table 14 – Ice – Yellow limit appears to be wrong – should it be $10 < I < 50$?	Revised accordingly.
Hutmacher	Table 15 – Ice – Yellow limit appears to be wrong – should it be $10 < I < 90$?	Revised accordingly.
Hutmacher	Figure 17 – Numbers don't agree with those in Sect 7.3.2, Table 10, Figure 21, or Figure ES-1.	Revised accordingly.

Hutmacher	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.	Revised accordingly.
Hutmacher	Tables 17 & 18 – Ice Factor– Explain how Green and Red limits were determined.	Revised accordingly.
Smith	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.	Revised accordingly.

6. Were there any critical results or limitations not discussed or adequately addressed in Sections 5, 6, 7, and 8 of the report?		
Reviewer	Comment	BSEE Comment Response
Berger	See answer to question number 5.	Noted.
	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?)	Revised to explain the limitations associated with induced wave energy using propellers for large events.
Brown	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.	Noted.
Brown	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.	Beyond the scope of the project.
Brown	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.	Noted.
Buck	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.	Provided additional detail to clarify.
Hutmacher	None other than that described in para 5 above.	Noted.

Smith	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.	Provided additional detail to clarify.
Smith	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.	Beyond the scope of the project.

7. Are the findings and overall interpretation of the results clearly discussed (Section 9)?		
Reviewer	Comment	BSEE Comment Response
Berger	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.	Clarified the narrative that the scope of the project was to determine when a given response option is feasible, not necessarily the effectiveness of the response option.
Berger	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.	Noted.
Berger	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.	Beyond the scope of this project.
Brown	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.	Noted.
Brown	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.	Noted.
Brown	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.	Noted.
Brown	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.	Noted.

Buck	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). 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.	Clarified in the narrative.
Hutmacher	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.	Noted.
Hutmacher	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.	Revised as appropriate.
Smith	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.	Revised to label/define x-axis and define units of y-axis, and included information in the discussion of the response tactic.

8. Are the conclusions (Section 11) logical and appropriate based on the results? Are there any additional conclusions that could be drawn?

<u>Reviewer</u>	<u>Comment</u>	<u>BSEE Comment Response</u>
Berger	The conclusions are well based the results of the analysis. See also answer to question number 7.	Noted.
Brown	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.	Noted.
Brown	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.	Noted.
Buck	Section 11 is more or less empty and do not provide any additional value.	Noted.
Buck	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.	Revised as appropriate.
Buck	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.	Revised as appropriate.
Hutmacher	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.	Revised as appropriate.
Hutmacher	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.	Revised as appropriate.
Smith	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.	Noted.

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

<u>Reviewer</u>	<u>Comment</u>	<u>BSEE Comment Response</u>
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Berger	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.	Noted.
Berger	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.	Noted.
Berger	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.	Noted.
Brown	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.	Noted.
Buck	I can only repeat what I wrote under General remarks in the beginning:	Noted.
Buck	“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.”	Noted.
Buck	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.	Noted.
Buck	No specific observation was provided.	Noted.
Hutmacher	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.	Noted.
Smith	Does this report present sufficient new data? No, it does not.	Noted.
Smith	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.	Noted.

Smith	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.	Noted.
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III Specific Observations

Reviewer	Comment	BSEE Comment Response
Berger	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.	Revised as appropriate.
Berger	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.	Revised as appropriate.
Brown	Reference for Living Oceans Society, 2011, in the last line of page 6 is not included in the list of references.	Revised as appropriate.
Brown	Reference to Alyeska’s Ship/Escort and Response Vessel System (SERVS) on page 9, is not listed in the list of references.	Revised as appropriate.
Brown	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.	Revised as appropriate.
Brown	Reference to Farmwald and Nelson, 1982 in the last paragraph on page 43, is not included in the list of references.	Revised as appropriate.
Brown	Reference - ARPEL Emergency Response Planning Working Group. (2007) is not cited in the text of the report.	Revised as appropriate.
Brown	Reference - National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling. (2011updated) is not cited in the text of the report.	Revised as appropriate.
Brown	Reference - Naval Postgraduate School. (2006) is not cited in the text of the report.	Revised as appropriate.
Brown	Reference - National Research Council. (1989) is not cited in the text of the report.	Revised as appropriate.
Brown	There are two references to Nuka Research, 2007 and 2007a, which is which in the reference section?	Revised as appropriate.
Brown	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.	Revised as appropriate.
Hutmacher	Executive Summary ☐ 1st para -last sentence	Revised as appropriate.
Hutmacher	Executive Summary ☐ 2nd para -last sentence -“Revised as appropriate.” and “three.”	Revised as appropriate.
Hutmacher	☐ 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.	Revised as appropriate.
Smith	No specific observation was provided.	Noted.

I. General Impressions

Reviewer	Comment	BSEE Comment Response
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Berger	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.	Noted.
Berger	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.	Noted.
Berger	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.	Noted.
Berger	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.	Noted.
Berger	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.	Noted.
Brown	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.	Noted.
Brown	It is clear that the authors have examined a large number of data sets and consulted with relevant subject matter experts and organizations.	Noted.
Brown	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.	Noted.
Brown	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.	Noted.
Brown	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.	Noted.

Brown	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.	Noted.
Buck	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.	Noted.
Buck	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.	Ask Nuka to discuss in body of report.
Buck	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.	Noted.
Buck	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.	Noted.
Hutmacher	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.	Revised as appropriate.

Smith	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.	Noted.
Smith	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.	Revised to clarify explanation. Limitations acknowledged and recommended for further research.
Smith	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.	Clarified meaning of "Scope of the Study". Explained logistical assumptions pertaining to equipment availability. Explained potential impacts on findings due to time increments used in the analysis.
Smith	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.	Revised as appropriate.