Center for Independent Experts (CIE) Review of the National Marine Fisheries Science (NMFS) Fisheries Climate Vulnerability Assessment

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Executive Summary

A panel from the Center of International Experts carried out a review on a Climate Vulnerability Analysis methodology for fish species that was developed by the US National Marine Fisheries Service (NMFS) of NOAA and tested in the Northeast US on 79 fish and invertebrate species. The methodology is designed to qualitatively assess the relative vulnerability of the abundance of exploited fish and invertebrate species to future climate changes. Fisheries and ecosystem experts from the NMFS used a series of life history attributes in combination with projections of the expected future changes in key physical and chemical characteristics (exposure variables) to identify the relative vulnerability of the various species to climate changes. These include both natural climate variability and anthropogenic climate change. The review panel found the methodology to be sound and consistent with other efforts to carry out similar types of analyses elsewhere. They concurred with the plan to apply the Climate Vulnerability Analysis in other US fisheries regions, although with some modifications and clarifications. These included a recommendation for a second set of reviewers, including non-NMFS experts from academia, nongovernmental organizations (NGOs) and the fishing industry, to redo the analysis to test the robustness of the method. This should ideally take place before the method is applied in the other US regions. For this application to other areas, the attributes used in the assessment should be similar in all regions although it is recognized that the exposure factors will differ slightly between regions owing to differences in the various region's physical and chemical conditions. While the climate variables in the Northeast Vulnerability Analysis were based upon a global model, regional downscaled models should be used where available.

Some of the terminology used in describing the procedure needs to be clarified and/or corrected to ensure that those doing the assessment, as well as those using the results, are clear on exactly what is meant. In addition, users of the results should be informed what the Vulnerability Analysis does and does not do to avoid misuse of the results. Certain of the attributes and how their rankings are to be determined need to be modified. Strongly correlated climate exposure variables should be eliminated. Future assessments should include ecosystem considerations, keystone species, species adaptive capabilities, and take into account the magnitude of the responses to climate changes. Because of the rapid pace of the climate changes along with the continual increase in information on their impact on fish and shellfish, re-assessments should take place approximately every five years or so. Finally the panel sees the need for funds to be made available for adequate training and implementation to ensure consistent application of the methods in different regions and for future re-assessments.

Background

To assess the vulnerability of a wide range of fish stocks in US waters to changing climate, the US National Marine Fisheries Service (NMFS) of NOAA convened a working group that developed a vulnerability methodology that incorporated elements of two prior marine species climate vulnerability assessments. Focusing upon the potential effects of climate change on the population abundance of various fish species, a case study to test the methodology was recently undertaken in the Northeast region of the US for 79 fish and invertebrate species. The Northeast region covers the Gulf of Maine, Georges Bank, and the Middle Atlantic Bight and also was extended northwards to include a small portion of the southern Scotian Shelf off Canada, as some

species cross the international boundary during some stage of their life. The methodology was designed to identify the relative vulnerability of exploited species based on a series of life history attributes and projections of the expected changes in key physical or chemical characteristics of the species' environment with future changes in the planet's climate system. This vulnerability information is intended to be used to help make decisions on how best to focus limited research and assessment resources (i.e. focus on stocks of highest concern). Additionally, the results are intended to promote discussion among scientists, managers, fishermen and other stakeholders about what climate-related changes are expected in marine ecosystems, how climate change may impact living marine resources, and what actions could be considered to reduce impacts and increase the resistance of these important marine resources to a changing climate.

NMFS plans to use this methodology to assess climate vulnerability of managed species in other regions of the US as part of the scientific advice provided to support fisheries management under the Magnuson-Stevens Act. In addition, the methodology will help meet several mandates for federal and state agencies to assess climate vulnerability and advance adaptation planning to promote resistance and/or resilience of valuable fish resources to climate changes.

The CIE review was carried out to assess the scientific credibility of the methodology including its structure and process, utilizing the results of the Northeast Assessment as a worked example. It was to determine whether the methodology meets its objectives, whether it is consistent with existing tools and approaches, whether changes are required to implement the methodology in different regions around the US, and the applicability of the methodology for future application to other NMFS resources.

Reviewer's Role in the Review Activities

The review panel consisted of three members covering expertise in fish (Dr. Jeff Hutchings, Canada), invertebrates (Dr. Nick Caputi, Australia) and in climate change and ecosystems (myself). The panel, plus its chair, Dr. Anne Hollowed from the NMFS in Seattle, met with the main members of the NMFS team that developed the methodology in Narragansett, Rhode Island during October 28-30, 2014. The NMFS team leaders were Drs. Jon Hare, Roger Griffis, Wendy Morrison and Mark Nelson. Review panel members Drs. Hutchings and Caputi had some previous experience with vulnerability analysis, but I did not. Prior to this meeting we were provided with a list of eight relevant papers to read in order to familiarize ourselves with the method and its application to the Northeast US waters. In addition we were given documents stating the review objectives, the panel's Terms of Reference (TORs), the species profile template, the definitions for the sensitivity attributes, and the profiles and narratives for six species including alewife, Atlantic cod, Atlantic croaker, Atlantic herring, Atlantic sea scallops and winter skate. Later, but still prior to the meeting, we were provided with 11 additional species profiles and narratives on Atlantic menhaden, Atlantic salmon, blueback herring, duskey shark, haddock, little skate, pollock, portbeagle shark, spiny dogfish, striped bass and yellowtail flounder. During the meeting we were given an additional six papers providing further background material.

During the first day the panel was given a brief introduction by Jon Hare, followed by Roger Griffis who told us what the objectives of the vulnerability assessment process are, mentioned

how the assessment framework was developed, how the case study using species in the Northeast US waters came about, why a review panel was considered necessary, and what our charge was. We were then introduced to the process by which the methodology was established by Dr. Wendy Morrison, which was followed after lunch with Dr. Mark Nelson going into detail on the methodology. During the presentations, as well as afterwards, all the panel members asked questions about and provided comments to the NMFS team.

On the second day, Jon Hare presented the implementation and results of the Northeast US Vulnerability Assessment (NEVA). In the afternoon three presentations by other NMFS scientists provided examples of how NEVA is being used. The first was by Dianne Borggaard from the Greater Atlantic Regional Fisheries Office (GARFO). She noted the usefulness of the NEVA in regards to the Endangered Species Act (ESA). It is an important tool for managers to inform them of potential climate change impacts on endangered species and in considering how important climate change considerations should be in species recovery plans. She indicated that a similar vulnerability assessment for marine mammals and sea turtles would be useful. The next presentation was by Camilla McCandless on dusky sharks. A review was carried out on this species because there had been a petition to list it as endangered. The NEVA was used to highlight the potential effects of climate changes on this species as well as the combined effects with other possible factors affecting its vulnerability to further declines in abundance. She also reviewed its use in Rhode Island's 2015 Revisions of its State Wildlife Action Plan that aims to identify species with the greatest conservation needs. This is part of a national framework of similar plans developed by each State that together create a national action agenda for preventing wildlife from becoming endangered. The third and last of the presentations was by Lisa Colburn. As part of the Magnuson-Stevens Act it is mandated that Social Impact Assessments be carried out as part of environmental impact assessments. Using Lubec, Maine, as a case study, she described an assessment of social impacts on the community involving factors such as poverty levels, housing, labour force, etc. Lubec's commercial income relies heavily upon fishing, primarily urchins and lobster. The NEVA helped to broaden the focus of the fisheries social impact assessments and improve both the measures of fishing community vulnerability and the ability to predict impacts to changing fishery management regimes and climate conditions Questions followed on these examples and the NEVA in general. A closed panel discussion was then held to provide input to the chair's upcoming report on the panel's main conclusions.

During day 3, the panel met with the chair to provide comments on a set of PowerPoint slides she had assembled as the basis of her report to NMFS leadership. The review panel members provided comments resulting in some modifications made to the report, which was given during the latter part of the morning via a conference call. After the conference call concluded, the review panel was thanked for their input and the meeting was closed.

Summary of Findings

Below are the major findings of the panel along with my comments and recommendations. The structure follows the panel's terms of reference.

Terms of Reference

1. *Evaluate and provide recommendations on the conceptual basis (vulnerability assessments) and design-process (workshops, pilots, NE implementation) for the NMFS Fisheries Climate Vulnerability Assessment.*

I believe that the conceptual basis for the vulnerability assessments as developed by the NMFS is reasonable to determine potential effects of climate on fish and shellfish population variability. Although not quantitative, it has the advantage of being applicable to all species, both marine and diadromous, and to whether there is a lot or only a small amount of data available pertaining to the different species. It can be used for identifying needs with regards to climate impacts on fish and potential fisheries and influencing strategic thinking in terms of deciding where NMFS resources should go in order to answer the most pressing questions. It needs to be acknowledged, however, that such an assessment is only one step along the way to understanding more fully the potential role of climate changes on fish species. In this regard it needs to be combined with other types of analyses and modeling.

As to the process implemented by the NMFS to develop the climate vulnerability assessment, I believe that they carried it out in a well-designed and efficient manner. Initially, a working group consisting of an expert from each NMFS science center and one from each regional office was formed to help develop the structural framework and methodology. This was done with much foresight given that the ultimate goal is to apply the assessment methodology to all US fisheries regions. The approach involving a large group should result in greater acceptance of the methodology when applied in the various regions than if it was only developed by a small team of researchers. The working group defined the life history characteristics (attributes) to be used in the assessment and a ranking method for each attribute (bins). Pilot tests were carried out using two regions (Northeast and Southeast). Based on these tests, the attribute definitions were modified. The assessment method was then applied in one region (the Northeast) as a case study. This too was a good strategy in my mind as it tested the method and helped iron out some of the problems before applying the methodology in other US regions. Together with the comments from the CIE review panel, it should make for a smoother application elsewhere in the US.

Having stated this, I have a number of recommendations, mostly related either to clarification rather than substantive changes to the methodology itself or to recommendations in future assessment analyses.

- I believe that a clearer statement of what the assessment framework does and does not do is needed. For example, while the assessment is examining the likelihood that the population levels of the different species will change in response to a changing climate, it does not indicate what the magnitude of the change in population abundance will be. It should also be emphasized that it is a vulnerability analysis of fish and not fisheries, although it can be used to speculate on some fisheries aspects.

- It needs to be clearly stated, that this vulnerability assessment is to changing climate, not necessarily anthropogenic climate change. The changes in climate include both natural climate variability and anthropogenic climate change. In the Atlantic, for example, there is a relatively high amplitude low frequency (period of 60-80 years) sea surface temperature

signal labelled the Atlantic Multidecadal Oscillation or AMO (see e.g. Sutton and Hodson, 2005). In recent years the AMO has been in its positive phase with increasing temperatures. Since many of the time series we are dealing with, especially on fish populations, are on the order of 30 to 40 years, near-linear temperature-induced population levels may appear to be due to anthropogenic forcing when in fact they may be part of the low frequency temperature variability related to the AMO. Therefore, one must be careful when attributing increases in temperature to a specific cause (climate change vs. climate variability). This needs to be communicated to the users of the assessment results so they will be careful not to attribute the cause of any warming solely to anthropogenic forcing (i.e. global warming).

- Being a vulnerability assessment, it naturally implies a negative connotation, i.e. a high ranking in the assessment implies that the particular species' population level is expected to be vulnerable to climate change and likely to decrease. However, we do expect that there will be some species whose population levels will likely increase (the winners under climate change). Such species will likely have a low ranking in terms of the assessment criteria. Other species that are expected not to vary under a changing climate would also have a low vulnerability ranking. It is thus strongly recommended that for those species for which the population is expected to increase that this be highlighted in the accompanying species narrative. This should help fisheries managers in their attempts to determine what effect climate changes will have on particular species.

- The assessment includes the likelihood of species distributional changes, either through expansion, retraction and/or a geographical shift. In the present assessment if a species is expected to shift its distribution (e.g. many species may shift their distribution northwards under increased warming), the present methodology does not make it susceptible to climate changes. While indeed the population abundance of such a species is not expected to be threatened by a changing climate, such shifts may take the fish out of (or new species into) an area traditionally fished including possibility into non-US waters (e.g. into Canadian waters in the case of the Northeast US). In such cases, the assessment rank itself will not be helpful to the fisheries managers or the fishing industry. It is therefore strongly recommended that where major distributional shifts are expected to occur, especially where they may lead to fish movements well away from traditional fishing grounds, that such potential effects on the fishing industry be highlighted in the accompanying narrative to the assessment results.

2. *Evaluate and provide recommendations on the assessment structure, assumptions, and scoring procedures for the NMFS Fisheries Climate Vulnerability Assessment including:*

a. *Does the methodology contain a valid list of attributes? Could any be added or removed?*

The vulnerability assessment in general contains a logical list of attributes for the purposes the assessment was designed for. It is clear that careful consideration was given to the choice of attributes. It is important when the methodology is applied in other regions that these attributes be the same in order to be able to adequately compare and contrast the results for different species and different regions. The attributes should, however, be revisited if and when a future

re-assessment is carried out. Having said this, I believe some modifications should be undertaken, if not on the planned application of the methodology to other US regions, then in subsequent applications. Some of these include the following.

- Under ocean acidification (OA) the ranking of low, medium and high are presently only based on OA effects on the species' prey, while a very high ranking is based on the perceived OA effects on the species itself. Both direct effects (on the taxa) and indirect (on their prey) should be combined in determining the species vulnerability to OA. The ultimate ranking would be determined on the highest ranking of the two. That is, if there were considered to be little OA effect on the prey (low rank) but a strong effect on the species itself (say a high rank), then the overall ranking would be high.

- In regards to temperature sensitivity, it must be remembered that for some species, there are different temperature ranges for different life stages. For example, young fish often are found in warmer temperatures and a narrower temperature range than adult fish. Consideration should be given in future to account for this aspect, by combining both adults and young juveniles in the temperature sensitivity. Given that the juveniles tend to stay in warmer waters than adults (at least for the species I am familiar with) perhaps it would not make a difference to the overall assessment of the temperature sensitivity; however, I think that juvenile temperature sensitivity should be considered at least in future assessments if not necessarily in the plans for the upcoming assessment in other US regions.

- Another issue related to temperature sensitivity is that the sensitivity depends to a certain degree upon the mean habit temperature. For example, for some species the response depends on whether the population is at the cold (usually the northern) end of its distributional range or the warm (usually southern) end. For example, different cod stocks react differently to temperature variability. For cold water cod stocks, warming temperatures tend to increase recruitment whereas for warm water cod stocks warming temperatures tend to decrease recruitment. Those stocks at intermediate temperatures show little to no response to temperature changes (see Planque and Fredou, 1999; Drinkwater, 2005). Therefore under climate change it has been suggested that the population levels for cold water stocks will likely increase while the warm water stocks will likely decrease (Drinkwater, 2005).

- For Stock Size Status, the panel suggests the B_{max} should be used rather than B_{MSY}.

- For the attribute on multiple stressors, a ranking based on the number of stressors seems somewhat arbitrary. It is likely true that if a species is stressed by several factors then it may be more susceptible to climate changes than if there is only one other stressor. However, it depends on the level of stress as one of the listed stressors alone may be enough to make the species highly susceptible to changes in climate, regardless of whether there are several others or not.

- For reproductive strategy, as with multiple stressors, the use of the number of complex strategies to determine the ranking seems somewhat arbitrary. If one strategy was very sensitive to climate changes, it should make a species ranking high or very high, even if

other reproductive strategies were not sensitive to climate but under the present assessment it would be assessed as low. It is clear that if there were several complex reproductive strategies it may make the species more susceptible to potential effects of climate changes. I am unclear what a better strategy than the one chosen should be however.

- For the early life history survival and settlement requirements, in the relationship to climate change section, it mentions both eggs and larvae. However, in the background section and the discussion on bin rankings, only larvae are considered. We do know that eggs can be sensitive to temperature, e.g. for cod, egg survival has been found from lab experiments to display a dome-shaped relationship with peak survival at 6°-8°C (Bigg et al., 2007). While the bin discussion of this attribute is in terms of recruitment variability and so this covers effects on both eggs and larvae, some discussion of the temperature effects on eggs could be included in the description to make it clear that one is truly considering both eggs and larvae.

- Under population growth, the review panel agreed that the attribution maximum age should be replaced by L_∞, which is a better measure of growth. Very few fish will attain the maximum age.

b. *Does the methodology appropriately account for expert bias?*

The NMFS team that developed the methodology has undertaken several steps to account for expert bias. First, they defined as clearly as they could the attributes and the scoring bins so that all experts would hopefully interpret the questions similarly. Second, after the initial assessment was carried out, a workshop was held in which the experts met to discuss their rankings and the thinking that went into the decisions they made. The experts were then given the chance to change their rankings (although they did not have to) after the discussion with the others. This could act to remove individual bias where one expert had detailed information that others did not have. Third, in the Northeast US assessment five experts (possible experts who were familiar with the species) were used to produce the assessment. An analysis was then performed in which the results of each expert were removed in turn (jackknife analysis) to determine how this affected the result. My understanding was that this analysis showed no significant difference in the results. A bootstrap analysis was also carried out to determine the uncertainty associated with each ranking and show where small changes in expert scores could result in a change in the overall vulnerability rank.

While I applaud the efforts that the team took to reduce the expert bias, I would recommend that (1) at least two sets of experts be selected to conduct the assessment and (2) that experts from both NMFS and non-NMFS institutions or organizations be chosen. Having a new set of experts will provide a further check on any possible expert bias and determine if the results are repeatable or not. Assuming such a process would show that the results are repeatable, this should go a long way to convincing other scientists and those potentially using the results that the method is robust. Academic and NGO experts should be amongst those chosen to redo the assessment. Other possibilities include DFO experts since some of the stocks are trans-boundary between the US and Canada, and stakeholders such as someone from the fishing industry. Although I do not believe that there would be a conscious NMFS bias, there may be an unconscious bias. In addition, if consistent results were obtained, it would help to convince those from outside the

NMFS of the validity of the results. The re-analysis would also provide a measure of the uncertainty of the results.

An added check on the methodology would be to compare the results from the Vulnerability Analysis with results from quantitative methods examining the effects of projected climate change for those species where the latter are available.

c. *Is the logic method appropriate?*

I believe that the logic method as applied in the assessment is appropriate. However, it is not without its concerns. The method can be sensitive to removal of one or more of the exposure variables, especially if it is one that tends to be one of the more important factors determining the end result. Also, the logic method does better in cases where there are several important factors and does less well when there is only a single exposure factor controlling the result.

d. *Is the methodology consistent with existing tools and approaches being used by other organizations to assess natural resource climate vulnerability?*

The methodology is indeed consistent with existing approaches being used by others to assess natural resource climate vulnerability. The NMFS team considered earlier efforts, especially those by the Australians and some Americans, and adapted them to develop the NMFS assessment methodology. Modifications included the use of the logic method instead of averages. Also, the team decided to combine the sensitivity with the exposure to determine the stock vulnerability, which differed from some of the other studies.

3. *Evaluate the strengths and weaknesses of the methodology.*

Some of the main strengths of the methodology developed by the NMFS include the following:

- The application of the methodology is relative easy.
- It requires limited data and therefore can be applied to both data-rich and data-poor species.
- It provides information on the reasons for the overall ranking.
- The results satisfy the requirement for consideration of climate change effects in various national assessments.
- The method highlights areas where further research is required.

Some of the main weaknesses of the methodology include the following:

- It does not include the magnitude of the expected change, only the direction, i.e. is not quantitative.
- It is susceptible to expert bias.
- Only one RCP was considered.
- It does not account for threshold effects.
- Results may depend heavily upon an exposure factor whose impact is largely unknown (e.g. OA).

- Assessments of distributional changes are generally not useful for fisheries.
- It is a relative assessment and therefore depends on what other species are used in the assessment.

4. *Evaluate and provide recommendations on the application of the NMFS Fisheries Climate Vulnerability Assessment using the Northeast region case study as an example.*

- The application of the Vulnerability Assessment to the Northeast US region fishes was a good first test of the methodology. The results were generally consistent with what one might expect given the methodology, although it was a bit surprising that only three exposure variables were deemed important, which were air temperatures, sea temperatures and ocean acidification.

- I recommend that the Northeast assessment be repeated with a second set of experts that should include non-NMFS personnel (see section 2a). This would determine the repeatability of the results, test any evidence of a NMFS bias, and help to assess the uncertainty of the results. In addition I understood that only one physical oceanographer was involved as an expert. Other physical oceanographers should be involved especially in terms of judging the exposure characteristics. While the judgment of the lone physical oceanographer is not being questioned, using other physical oceanographers would help to strengthen the validity of the results and its robustness.

- It was noted that the assessment was based entirely on the Greenhouse Gas RCP (Representative Concentration Pathway) 8.5. This RCP is characterized by increasing greenhouse gas emissions over time that lead to high greenhouse gas concentration levels. It represents the most pessimistic of the RCPs. This needs to be stated very clearly in the method description. Ideally, it would be good to repeat the assessment using another RCP, which would result in lower exposure factors. The least that should be done is to discuss what the effects of the results would be if one used a lower RCP.

- The spatial scale of the assessment is defined by the selected region of interest, in this case primarily the Gulf of Maine, Georges Bank and the Middle Atlantic Bight. I believe that it needs to be made clear to the users of the results that the results only apply to this region and not farther afield (unless there is clear evidence that the results are generally applicable for all locations). Because the assessment is regional and I believe it should be, I think that the assessment should be on stocks, if sufficient data are available. For example, a vulnerability assessment for cod, herring or mackerel on a species level would require examining the exposure and distributions over large areas of the North Atlantic. This was not carried out in this assessment, nor should it be. Information on the stock structure is limited for many of the species and this makes it difficult or impossible to consider the assessment on the stock level for many of the species. However, for those species where the stock information and data are available, the assessment should be undertaken at the stock level. Atlantic cod is one such species where we know that the responses to climate changes vary with location, i.e. stock. The assessment in the Northwest region on this species is valid for the stocks in this region but not to all cod stocks. Therefore if the

assessment is stated as being done on a species level, it needs to be made clear that it was done within the confines of the Northwest region and is not necessarily applicable to other regions. One could say that the results are applicable to the Gulf of Maine-Georges Bank-Middle Atlantic Bight stocks if treated together in the assessment, or if treated separately (this assumes one has the climate exposure factors on the spatial scale of the stocks) then on an actual stock basis.

- In regards to the exposure factors, the panel agreed that highly correlated factors should be removed. The discussion arose around the use of both air temperatures and sea temperatures as exposure factors. The air temperatures were included as a proxy variable for shallow water temperatures, including the temperatures in rivers and lakes, which can be important for diadromous species. I was particularly concerned because both were considered representative of sea temperatures and presumably are highly correlated, thus the assessment was in fact weighing temperature twice. This was even more troubling to me because for the Northeast US assessment these two temperature factors (along with ocean acidification) were generally the only ones determining a species vulnerability to a changing climate. In the case of OA it was ranked high mainly because we did not know very much about its effect on the various species. For this reason, the results are probably over sensitive to OA. For the two temperature indices, it is true that for diadromous species they can be under threat from increasing temperatures when they are in freshwater or in the marine environment. The potential of extreme temperatures, even lethal temperatures, in shallow rivers or lakes is likely the most threatening of the two. One could argue that this makes diadromous species more vulnerable than marine only species because they are threatened by conditions in both fresh and marine waters and to this I agree. However, I still am concerned that the assessment is considering temperatures twice. My recommendation is to investigate the relationship between air and sea temperatures over the spatial and temporal scales of interest. If, as I expect, these two are highly correlated, I would tend just to use sea temperatures and not include air temperatures. If the two are not strongly correlated then use both, but in terms of the assessment, combine the two so that the temperature effect is only considered once. For example, for diadromous species use the ranking based on the higher of the air or sea temperature. If the vulnerability to air temperature exposure is considered high implying possible high freshwater temperatures, the rank for the overall temperature vulnerability would be high even if there is no expected temperature effect on species while in the marine environment.

- In future assessments, the use of a downscaled regional climate model is recommended. The advantage of the more finely-resolved downscaled model is that it can better highlight possible spatial differences in the exposure factors. It should also provide information on mesoscale features such as eddies and fronts. The downscaling results will depend to a large extent on the global model from which the downscaling was done. To obtain the best results, carefully choose which global models to downscale from. Choose those which perform best in the Northeast region by examining how well they do in hindcasting recent years. It is probably best to choose several global models and then form an ensemble average from the different downscaled models.

5. *Provide a recommendation as to whether the methodology provides results and information that can assist U.S. federal, state, and local fishery managers in understanding and considering possible climate impacts on fish stocks (fishery includes exploited shellfish and finfish species).*

   The methodology has been designed to determine if the population level of fish and shellfish species are vulnerable to changes in climate and in this regard, such information can indeed assist fisheries managers at all levels of government. It was clear from the three presentations given on day 2 of the review that the Northeast US assessment has already helped some managers meet their objectives. The vulnerability assessment will become increasingly important since US legislation is dictating that climate effects must be taken into account when considering fish populations related to such issues as endangered species, wildlife protection plans, or societal impact assessments. The assessments can also point out where more research is needed to improve the results. For example, it is clear from the NEVA that much more research is needed on the impact of ocean acidification on fish and shellfish. The assessments can also be used, in conjunction with other information such as the value of a fishery or a species role in the ecosystem, to determine which species one should focus research resources upon.

   It must be recognized, however, that the assessment is restricted to the vulnerability of population levels changing in response to climate. Also, it is a relative ranking and not an absolute one, that is it indicates that species A is more or less vulnerable than species B. It does not provide information on the magnitude of the changes in population abundance. In addition, while geographical shifts or changes in location are dealt with within the assessment, it does not provide the information necessarily needed for the fisheries managers. Species shifts (or expansions) can make a species less vulnerable to climate changes. The population, while moving its boundaries, may not change or even expand its population level. What fisheries managers need in regards to distributional shifts is the extent of the changes, especially if they make the species less or more vulnerable to the local fishing industry. In the case of those US regions adjacent to Canada, Mexico or Russia, distributional shifts could take fish into areas where they are now totally unavailable the fishing.

6. *Provide a recommendation as to whether the methodology is appropriate for use in other regions. Has it provided useful information in the Northeast and could it provide useful information in other regions?*

   I recommend that the methodology be used in other regions of the US. This is based on my belief that the methodology has provided useful information in the Northeast US, which was reinforced to me by the three presentations outlining how the assessment has been used in recent analyses (e.g., its application with regard to the Endangered Species Act, the vulnerability assessment of dusky sharks, and the Societal Impact Assessment). The results from other regions could be used similarly, and no doubt for many other purposes. The NMFS team that developed the methodology indicated that some of their members would be on hand to help guide the assessments in the other regions. This I believe is mandatory. There are a number of considerations and recommendations when applying the assessment methodology to these other regions.

- Most of the exposure factors should be the same as in the Northeast assessment but there will have to be region specific exposure factors. For example, oxygen is an important factor in the Caribbean region especially around the Mississippi River, and off the California coast, that could affect several species. Sea ice will need to be considered in the Bering Sea.

- The attributes should be consistent with those used in the Northeast in order to compare the results. Also, this will be useful for testing and assessing the methodology and how influential the attributes are in determining the results.

- Certainly in the Bering Sea and the California Current system, there are downscaled models that could be used to determine the distribution of the exposure factors. I am uncertain whether such models are available in the Southeast or in the Caribbean. Where available, such models should be used. If used in addition to the global models, comparisons could be made to determine how important model resolution is to the results.

- In the Northeast US assessment, the exposure was based upon the difference in the means of the climate factor between 2006 to 2055 and 1956 to 2005 divided by the standard deviation in the latter period. The future time period was chosen as it was considered to be within the time frame where fisheries managers and the fishing industry may be interested but still far enough into the future that anthropogenic climate change should be significant and perhaps even dominate in comparison to natural variability, at least towards the end of the period. Still, the average for the period 2006 to 2055 will most likely be strongly influenced by natural variability.

- For the estimate of the exposure, having an equal length earlier period to which the future is compared makes sense. However, one must to careful given that some regions are impacted by decadal or multidecadal variability more than other regions, which will influence what the length of the period should be. Also, the length of the climate time series in some regions may be shorter than the 50 years chosen for the Northeast. If a meaningful comparison of the results between regions is to be carried out, then a standard period in all regions is required.

- To map the distribution of the various species for the NEVA for comparison with the distribution of the exposure factors, the Ocean Biogeographic Information System (OBIS) database was used. While it is recommended that this database be used in other regions, it appears that the OBIS database is not up-to-date in all regions. Other databases or data sources may have to be used. For consistency, it is recommended to use the OBIS database but up-date it where and if possible.

7. *Provide recommendations for possible ways to improve the methodology or its application / use.*

- The review panel found a number of inconsistencies in the terminology used in the assessment criteria. Careful consideration should be given to insure that all terms are used correctly and consistently. They need to be carefully defined and/or described to avoid any possible confusion of interpretation especially to the experts carrying out the assessment. As pointed out in the chairperson's report, both risk and vulnerability analyses have been used in reference to the assessment. The similarity or difference between these two should be defined up front but then only one used throughout the documents. I would recommend vulnerability analysis since that is the term most often used. The term resilience, which is the ability for a species to recover from a low population level, is often used when in fact the term resistance is meant, i.e. the ability to lessen the affect, in this case of climate changes.

- In future assessments thought should be given to the application to ecosystems, not just to individual species or stocks. This will, by necessity, require careful thought and consideration. We know from previous studies that the linear combination of individual species responses do not necessary lead to the same result as treating the ecosystem as a whole. This is due, among other things, to species interactions and feedbacks through predator-prey relationships, competition, and temporal variability in the time lags between climate changes and different species responses, and the amplitude of the responses to climate changes. One aspect that should be included if an ecosystem analysis was undertaken would be towards the effects of a changing climate on primary and secondary production. What will happen to general productivity in the regions under climate change? With the regional models that have been developed or are being developed such a question can be addressed. It is very important and may play a leading role in whether the species population levels will decline under climate change.

- The vulnerability assessment has been, in the case of the Northeast US region, mainly applied to commercial species of fish and invertebrates. I would recommend that a similar assessment should also be applied to species that play key roles in the ecosystem but are not necessarily commercially exploited. An example is forage fish. In this regard, within the Northeast US region, a vulnerability assessment should have been carried out on sand lance, which is an important prey item for groundfish such as Atlantic cod.

- We know that warm water corals are highly sensitive to warming ocean temperatures with many corals dying due to lethal temperatures. Around the northern US regions, there are areas with cold water corals. I know that our knowledge on these, including even where they are located, is rudimentary at best so that an assessment of the vulnerability of these corals to climate changes will suffer from a lack of information. However, I think that in future assessments they should be included, if only to indicate this gap in our knowledge. While not of direct commercial value, their role in ecosystems is unclear although it has been suggested that they may play a role as nursery grounds for some fish species.

- The vulnerability assessment in the Northeast dealt mostly on the species level but I believe that it should be done on stocks, where possible. This is especially applicable if the species extends well beyond the geographic area where the assessment is being applied. For example, the range of Atlantic cod stocks extends from about 35° to 80°N, covering a wide range of environmental conditions. Individual cod stocks have shown an amazing ability to adapt to local environmental conditions. For example, several of the stocks inhabiting very cold waters have certain proteins in their blood that act like antifreeze whereas those in warm waters do not contain these proteins. Different cod stocks react differently to temperature variability. As previously mentioned, for cold water cod stocks, warming temperatures tend to increase recruitment whereas for warm water cod stocks warming temperatures tend to decrease recruitment. Under such circumstances it makes more sense to consider the response of the individual stocks than to the species as a whole. For cod it also indicates that this species can adapt well to local conditions given enough time.

- Another possibility for future assessments is the inclusion of the adaptive capability of the various species to evolve, either genetically or not. The present assessment assumes that the species will not evolve under climate change, which is unlikely to be the case, most noticeably in the long-term. Determining how to include the evolutionary process in the assessments may be difficult as little data are available on this. However, it is another subject that may be worth including, again for no other reason than to indicate we need more research in this area.

- Because of the rapid pace of the climate changes along with the continual increase in information on their impact on fish and shellfish, I believe that re-assessments should take place approximately every 5 years or so.

8. *Provide a brief description on the panel review proceedings highlighting pertinent discussions, issues, effectiveness, and recommendations.*

I think that the panel review proceedings were highly efficient and allowed for ample time for discussions with, and questions to, the primary NMFS team members (Wendy Morrison, Mark Nelson, Jon Hare and Roger Griffis). The logical progress from introduction of the main objectives of the assessment, to the general framework including exposure factors, attributes, and scoring, worked well. The major discussion areas during the presentation by Wendy Morrison on the process for establishing the methodology were on the various attributes and the sensitivity analysis. This resulted in a number of comments and recommendations for improvement or modification. During the presentation by Mark Nelson on details about the methodology, questions arose regarding the choice of the particular methodological framework that was chosen, on the data quality issues, and on the scoring procedures. Again several comments and recommendations were made by the panel. On day 2 of the meeting, the primary discussions took place during Jon Hare's presentation on the application of the method to the Northeast US region. Questions arose on the expert analysis, on particular species, on downscaled models versus global models, on climate exposures including whether there was overlap using both air and sea temperatures, and how the results can be displayed most effectively. These discussions led to several recommendations that appear throughout

this report. I felt that the review procedures were very efficient and highly useful in exchanging ideas and information about the process.

9. *Panel Chair is to prepare a short summary to be presented to NMFS Fisheries Climate Vulnerability Assessment leads and NMFS Leadership at the end of the Panel Review (Day 3)*

   The Panel Chair (Dr. Hollowed) presented a short summary to the NMFS Fisheries Climate Vulnerability Assessment leads and NMFS Leadership in the late morning of day 3 based upon input from the Review Panel. She initially developed a set of PowerPoint slides that attempted to summarize the major comments and recommendations of the review panel that arose during our first 2 days of discussions. During the first part of the morning of day 3, the review panel went through the slides with the chair and provided suggestions for modifications to the slides, which she accepted.

Comments on the species profile for Atlantic Cod

I had noticed a couple of statements in the profile on Atlantic cod that I thought were not clear or incorrect. While the species profiles are not considered a product of the review, I thought I would indicate those statements I had concern about in case these profiles will be used the next time a review is carried out. I had not gone through many of the species profiles as I have less knowledge on the details of the other species whose profiles we were provided with.

Statement in profile regarding species range of cod: *Min and Max Latitude: 44.25 - 36.94°N, High Presence Latitude: 43.94 - 41.74°N. Stopped at southwestern Nova Scotia.*

My comment: I assume that this only refers to Gulf of Maine cod since Atlantic cod extend up to almost 80°N in the Barents Sea. In terms of temperatures, adult cod can be found in waters of <-1°C to over 20°C but the annual mean temperatures of the various cod stocks around the North Atlantic tend to vary between approximately 2°-11°C with no cod stocks found inhabiting waters with annual mean temperatures >12°C (Brander, 1994; Planque and Fredou, 1999; Drinkwater, 2005). If strictly referring to the latitudinal range of Gulf of Maine cod, it should have been more clearly specified.

Statement in profile regarding larval food: *In spring, Atlantic cod (*Gadus morhua*) spawned progressively later from southwest to northeast along the Scotian Shelf and matched the variation in peak abundance of* Calanus finmarchicus*. In fall, cod spawned in some, but not all, areas where* Calanus *were abundant. This is consistent with the hypothesis that cod spawning is coupled to copepod production, which is a part of the "match–mismatch" hypothesis proposed by D. H. Cushing.*

My comment; While the larvae of many cod stocks prey mainly on *Calanus finmarchicus*, those spawning in the southern limits of their geographic range, including on Georges Bank and in the Gulf of Maine, tend to feed primarily on *Psuedocalanus* (Heath and Lough, 2007).

I note however that even if these profile statements were included it likely would not have made much of a difference in the overall ranking of the vulnerability of cod in the Northeast US.

Conclusions and Recommendations

The major conclusions regarding the Vulnerability Analysis were:

- It is a useful procedure to qualitatively assess the potential effects of future climate changes on the abundance of fish and shellfish species. The NMFS team that developed the strategy is to be commended.
- The method highlights areas where further research is required and can be used, along with other considerations (e.g. value of the fishery, role in the ecosystem, etc.), to help decide where research resources should be spent.
- The application in the Northeast US (NEVA) was a good test case and was needed before broader application to other US regions. A second set of reviewers that includes non-NMFS experts from academia, NGOs and the fishing industry should be considered to test the robustness of the method, ideally before application to other US regions.
- The Vulnerability Analysis should be carried out in other US fisheries regions as planned, although consideration should be given to the panel's recommendations for modifications and clarifications before this is carried out. The attributes should be similar throughout all regions although the exposure factors may differ slightly between regions owing to differences in the physical and chemical conditions. Regional downscaled models should be used where available but for comparisons with those regions without such models, a second analysis using global models should be carried out.

Some other important recommendations include:

- Terminology needs to be clarified and/or corrected to ensure that those doing the assessment, as well as those using the results, are clear on exactly what is meant.
- All assumptions also need to be clearly spelled out.
- Users need to be informed what the Vulnerability Analysis does and does not do to avoid misuse of the results.
- Certain attributes and how their rankings are to be judged need to be modified (see comments under ToR 2a).
- Remove highly correlated climate exposure variables.
- Future assessments should include ecosystem considerations, keystone species, species adaptive capabilities, and the magnitude of the responses to climate changes.
- Because of the changing climate and increased information being continually gathered, re-assessments should take place approximately every 5 years.
- Funds should be made available for adequate training and implementation to ensure consistent application of the methods and for future re-assessments.

Appendix 1: Bibliography of materials provided for review
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Appendix 2: CIE Statement of Work

External Independent Peer Review by the Center for Independent Experts

NMFS Fisheries Climate Vulnerability Assessment Review

Scope of Work and CIE Process: The National Marine Fisheries Service's (NMFS) Office of Science and Technology coordinates and manages a contract providing external expertise through the Center for Independent Experts (CIE) to conduct independent peer reviews of NMFS scientific projects. The Statement of Work (SoW) described herein was established by the NMFS Project Contact and Contracting Officer's Technical Representative (COTR), and reviewed by CIE for compliance with their policy for providing independent expertise that can provide impartial and independent peer review without conflicts of interest. CIE reviewers are selected by the CIE Steering Committee and CIE Coordination Team to conduct the independent peer review of NMFS science in compliance the predetermined Terms of Reference (ToRs) of the peer review. Each CIE reviewer is contracted to deliver an independent peer review report to be approved by the CIE Steering Committee and the report is to be formatted with content requirements as specified in **Annex 1**. This SoW describes the work tasks and deliverables of the CIE reviewer for conducting an independent peer review of the following NMFS project. Further information on the CIE process can be obtained from *www.ciereviews.org*.

Project Description: Through in-depth investigations of specific fish stocks, NMFS has a strong understanding of how climate change may impact some high profile fish species (e.g. Hare et al. 2010, Hollowed et al. 2009, Hazen et al. 2012). However, repetition of these detailed analyses for all managed stocks (~450) is not feasible as these studies are resource intensive and require data sets that are not available for many fish stocks. Given the pace at which climate change is expected to occur and the need for NMFS to develop science priorities and management considerations now, there has been a demand to develop a practical and efficient tool to assess the vulnerability of a wide range of fish stocks in a changing climate. This tool would not replace detailed studies. Rather, it is designed to provide information until detailed studies can be completed and to help guide more detailed studies by identifying high risk species and important climate factors. To develop this tool - a climate vulnerability assessment for marine fish and invertebrate species - NMFS convened a working group composed of fishery scientists and managers from across the country. The methodology was built off a standard vulnerability assessment framework and specifically incorporated elements of two prior marine species climate vulnerability assessments. The methodology was recently implemented in the Northeast region for 79 fish and invertebrate species. This methodology was designed to identify the relative vulnerability of exploited species based on a series of life history attributes and projections of the expected changes in key physical or chemical characteristics of the species' environment with changes in the planet's climate system. The vulnerability information is intended to be used to help inform considerations of how best to focus limited research and assessment resources (e.g., focus on stocks of highest concern). Additionally, the results are intended to promote conversation among scientists, managers, fishermen and other stakeholders about what climate-related changes are expected in marine ecosystems, how climate change may impact living

marine resources, and what actions could be considered to reduce impacts and increase resilience of these important marine resources in a changing climate.

NMFS plans to use this methodology to assess climate vulnerability of managed species in other regions as part of the scientific advice provided to support fisheries management under the Magnuson-Stevens Act. Vulnerability assessments are now being used extensively by federal, state and tribal natural resource agencies and partners to identify key resources at risk and inform planning for how to reduce risks and increase resilience in a changing climate. In addition, the methodology is responsive to several mandates for federal agencies to assess climate vulnerability and advance adaptation planning to promote resilience of natural resources (e.g., Executive Order 13653 "Preparing the United States for the Impacts of Climate Change"; National Fish Wildlife and Plants Climate Adaptation Strategy, and the National Ocean Policy).

The objective of the CIE review is to assess the scientific credibility of the methodology including its structure and process, utilizing the results of the Northeast Assessment as a worked example. Key questions for the CIE review are:

- Does the methodology adequately meet its design goals and objectives?
- Is it consistent with existing tools and approaches being used by other organizations to assess natural resource climate vulnerability?
- Do the results assist federal, state or tribal fisheries managers in understanding and considering possible impacts of climate change on fish stocks?
- Are there changes or modifications that should be made before implementing in different regions?
- Are there improvements that can be made in the implementation of the methodology based on the worked exampled in the Northeast?
- Does the methodology provide a useful framework or model for possible application to other NMFS trust resources (e.g., protected species, endangered species, and critical habitats)?

We envision a three-day review. Day one will focus on the methodology. Day two will focus on the implementation in the Northeast. Day three will provide the review panel time for discussion and preparation of their review and also a summary meeting with the methodology designers and members of NMFS leadership. The Terms of Reference (ToRs) of the peer review are attached in **Annex 2**. The tentative agenda of the panel review meeting is attached in **Annex 3**.

Requirements for CIE Reviewers: CIE reviewers shall conduct an impartial and independent peer review in accordance with the SoW and ToRs herein. CIE reviewers shall have a combination of the following expertise: the application of natural resource climate vulnerability assessments, ecosystem-based approaches to natural resource management, and climate change effects on marine species and ecosystems. We do not expect all of these skills to be represented by each reviewer, but request that review panel as a whole have the expertise to cover the topics listed above. Vulnerability assessments have been widely used in terrestrial systems and terrestrial scientists with experience in vulnerability assessments would be appropriate. Each CIE reviewer's duties shall not exceed a maximum of 14 days to complete all work tasks of the peer review described herein.

The chair or the panel will be chosen by NMFS and will be a fisheries scientist with an understanding of current marine fisheries issues in the Northeast Region.

Location of Peer Review: Each CIE reviewer shall conduct an independent peer review during the panel review meeting scheduled in Narragansett, Rhode Island from 28-30 October 2014.

Statement of Tasks: Each CIE reviewer shall complete the following tasks in accordance with the SoW and Schedule of Milestones and Deliverables herein.

Prior to the Peer Review: Upon completion of the CIE reviewer selection by the CIE Steering Committee, the CIE shall provide the CIE reviewer information (full name, title, affiliation, country, address, email) to the COTR, who forwards this information to the NMFS Project Contact no later the date specified in the Schedule of Milestones and Deliverables. The CIE is responsible for providing the SoW and ToRs to the CIE reviewers. The NMFS Project Contact is responsible for providing the CIE reviewers with the background documents, reports, foreign national security clearance, and other information concerning pertinent meeting arrangements. The NMFS Project Contact is also responsible for providing the Chair a copy of the SoW in advance of the panel review meeting. Any changes to the SoW or ToRs must be made through the COTR prior to the commencement of the peer review.

Foreign National Security Clearance: When CIE reviewers participate during a panel review meeting at a government facility, the NMFS Project Contact is responsible for obtaining the Foreign National Security Clearance approval for CIE reviewers who are non-US citizens. For this reason, the CIE reviewers shall provide requested information (e.g., first and last name, contact information, gender, birth date, passport number, country of passport, travel dates, country of citizenship, country of current residence, and home country) to the NMFS Project Contact for the purpose of their security clearance, and this information shall be submitted at least 30 days before the peer review in accordance with the NOAA Deemed Export Technology Control Program NAO 207-12 regulations available at the Deemed Exports NAO website: http://deemedexports.noaa.gov/
http://deemedexports.noaa.gov/compliance_access_control_procedures/noaa-foreign-national-registration-system.html

Pre-review Background Documents: Two weeks before the peer review, the NMFS Project Contact will send (by electronic mail or make available at an FTP site) to the CIE reviewers the necessary background information and reports for the peer review. In the case where the documents need to be mailed, the NMFS Project Contact will consult with the CIE Lead Coordinator on where to send documents. CIE reviewers are responsible only for the pre-review documents that are delivered to the reviewer in accordance to the SoW scheduled deadlines specified herein. The CIE reviewers shall read all documents in preparation for the peer review.

1. Methodology Manuscript
    a. Database Description
    b. Sensitivity Attribute Definition Document
2. Northeast Application Manuscript
    a. Exposure Factor Definition Document

   b. Species Profiles Example
   c. Species Narrative Examples
3. Chin et al. (2009) Paper
4. Johnson and Welch (2009) Paper
5. Moyle et al.(2013) Paper
6. Pecl et al. (2011) Report
7. Foden et al. (2013)
8. National Wildlife Foundation - A Guide to Climate Change Vulnerability Assessment

For more examples see: http://www.natureserve.org/conservation-tools/standards-methods/climate-change-vulnerability-index.

Panel Review Meeting: Each CIE reviewer shall conduct the independent peer review in accordance with the SoW and ToRs, and shall not serve in any other role unless specified herein. **Modifications to the SoW and ToRs can not be made during the peer review, and any SoW or ToRs modifications prior to the peer review shall be approved by the COTR and CIE Lead Coordinator.** Each CIE reviewer shall actively participate in a professional and respectful manner as a member of the meeting review panel, and their peer review tasks shall be focused on the ToRs as specified herein. The NMFS Project Contact is responsible for any facility arrangements (e.g., conference room for panel review meetings or teleconference arrangements). The NMFS Project Contact is responsible for ensuring that the Chair understands the contractual role of the CIE reviewers as specified herein. The CIE Lead Coordinator can contact the Project Contact to confirm any peer review arrangements, including the meeting facility arrangements.

Contract Deliverables - Independent CIE Peer Review Reports: Each CIE reviewer shall complete an independent peer review report in accordance with the SoW. Each CIE reviewer shall complete the independent peer review according to required format and content as described in Annex 1. Each CIE reviewer shall complete the independent peer review addressing each ToR as described in Annex 2.

Other Tasks – Contribution to Summary Report: Each CIE reviewer may assist the Chair of the panel review meeting with contributions to the Summary Report, based on the terms of reference of the review. Each CIE reviewer is not required to reach a consensus, and should provide a brief summary of the reviewer's views on the summary of findings and conclusions reached by the review panel in accordance with the ToRs.

Specific Tasks for CIE Reviewers: The following chronological list of tasks shall be completed by each CIE reviewer in a timely manner as specified in the **Schedule of Milestones and Deliverables**.

1) Conduct necessary pre-review preparations, including the review of background material and reports provided by the NMFS Project Contact in advance of the peer review.
2) Participate during the panel review meeting at Narragansett, Rhode Island from 28-30 October 2014 as specified herein, and conduct an independent peer review in accordance with the ToRs (**Annex 2**).
3) No later than 14 November 2014, each CIE reviewer shall submit an independent peer review report addressed to the "Center for Independent Experts," and sent to Dr. Manoj

Shivlani, CIE Lead Coordinator, via email to mshivlani@ntvifederal.com, and Dr. David Sampson, CIE Regional Coordinator, via email to david.sampson@oregonstate.edu. Each CIE report shall be written using the format and content requirements specified in Annex 1, and address each ToR in **Annex 2**.

Schedule of Milestones and Deliverables: CIE shall complete the tasks and deliverables described in this SoW in accordance with the following schedule.

Please provide the actual dates in the following table. Please use this table format.

22 September 2014	CIE sends reviewer contact information to the COTR, who then sends this to the NMFS Project Contact
14 October 2014	NMFS Project Contact sends the CIE Reviewers the pre-review documents
28-30 October 2014	Each reviewer participates and conducts an independent peer review during the panel review meeting
14 November 2014	CIE reviewers submit draft CIE independent peer review reports to the CIE Lead Coordinator and CIE Regional Coordinator
28 November 2014	CIE submits CIE independent peer review reports to the COTR
5 December 2014	The COTR distributes the final CIE reports to the NMFS Project Contact and regional Center Director

Modifications to the Statement of Work: This 'Time and Materials' task order may require an update or modification due to possible changes to the terms of reference or schedule of milestones resulting from the fishery management decision process of the NOAA Leadership, Fishery Management Council, and Council's SSC advisory committee. A request to modify this SoW must be approved by the Contracting Officer at least 15 working days prior to making any permanent changes. The Contracting Officer will notify the COTR within 10 working days after receipt of all required information of the decision on changes. The COTR can approve changes to the milestone dates, list of pre-review documents, and ToRs within the SoW as long as the role and ability of the CIE reviewers to complete the deliverable in accordance with the SoW is not adversely impacted. The SoW and ToRs shall not be changed once the peer review has begun.

Acceptance of Deliverables: Upon review and acceptance of the CIE independent peer review reports by the CIE Lead Coordinator, Regional Coordinator, and Steering Committee, these reports shall be sent to the COTR for final approval as contract deliverables based on compliance with the SoW and ToRs. As specified in the Schedule of Milestones and Deliverables, the CIE shall send via e-mail the contract deliverables (CIE independent peer review reports) to the COTR (William Michaels, via William.Michaels@noaa.gov).

Applicable Performance Standards: The contract is successfully completed when the COTR provides final approval of the contract deliverables. The acceptance of the contract deliverables shall be based on three performance standards:
(1) The CIE report shall completed with the format and content in accordance with **Annex 1**,
(2) The CIE report shall address each ToR as specified in **Annex 2**,
(3) The CIE reports shall be delivered in a timely manner as specified in the schedule of milestones and deliverables.

Distribution of Approved Deliverables: Upon acceptance by the COTR, the CIE Lead Coordinator shall send via e-mail the final CIE reports in *.PDF format to the COTR. The COTR will distribute the CIE reports to the NMFS Project Contact and Center Director.

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Annex 1: Format and Contents of CIE Independent Peer Review Report

1. The CIE independent report shall be prefaced with an Executive Summary providing a concise summary of the findings and recommendations, and specify whether the science reviewed is the best scientific information available.

2. The main body of the reviewer report shall consist of a Background, Description of the Individual Reviewer's Role in the Review Activities, Summary of Findings for each ToR in which the weaknesses and strengths are described, and Conclusions and Recommendations in accordance with the ToRs.

   a. Reviewers should describe in their own words the review activities completed during the panel review meeting, including providing a brief summary of findings, of the science, conclusions, and recommendations.

   b. Reviewers should discuss their independent views on each ToR even if these were consistent with those of other panelists, and especially where there were divergent views.

   c. Reviewers should elaborate on any points raised in the Summary Report that they feel might require further clarification.

   d. Reviewers shall provide a critique of the NMFS review process, including suggestions for improvements of both process and products.

   e. The CIE independent report shall be a stand-alone document for others to understand the weaknesses and strengths of the science reviewed, regardless of whether or not they read the summary report. The CIE independent report shall be an independent peer review of each ToRs, and shall not simply repeat the contents of the summary report.

3. The reviewer report shall include the following appendices:

   Appendix 1: Bibliography of materials provided for review
   Appendix 2: A copy of the CIE Statement of Work
   Appendix 3: Panel Membership or other pertinent information from the panel review meeting.

Annex 2: Terms of Reference for the Peer Review

NMFS Fisheries Climate Vulnerability Assessment Review

1. Evaluate and provide recommendations on the conceptual basis (vulnerability assessments) and design-process (workshops, pilots, NE implementation) for the NMFS Fisheries Climate Vulnerability Assessment
2. Evaluate and provide recommendations on the assessment structure, assumptions, and scoring procedures for the NMFS Fisheries Climate Vulnerability Assessment including:
    a. Does the methodology contain a valid list of attributes? Could any be added or removed?
    b. Does the methodology appropriately account for expert bias?
    c. Is the logic method appropriate?
    d. Is the methodology consistent with existing tools and approaches being used by other organizations to assess natural resource climate vulnerability?
3. Evaluate the strengths and weaknesses of the methodology
4. Evaluate and provide recommendations on the application of the NMFS Fisheries Climate Vulnerability Assessment using the Northeast region case study as an example.
5. Provide a recommendation as to whether the methodology provides results and information that can assist U.S. federal, state, and local fishery managers in understanding and considering possible climate impacts on fish stocks (fishery includes exploited shellfish and finfish species)
6. Provide a recommendation as to whether the methodology is appropriate for use in other regions. Has it provided useful information in the Northeast and could it provide useful information in other regions?
7. Provide recommendations for possible ways to improve the methodology or its application / use.
8. Brief description on panel review proceedings highlighting pertinent discussions, issues, effectiveness, and recommendations
9. Panel Chair prepare a short summary to be presented to NMFS Fisheries Climate Vulnerability Assessment leads and NMFS Leadership at the end of the Panel Review

Annex 3: Tentative Agenda

NMFS Fisheries Climate Vulnerability Assessment Review

Narragansett, Rhode Island
Security POC: Jon Hare

Day 1 – 28 October 2014

9:00-9:15	Introductions / Logistics
9:15-9:30	Charge to the Review Panel (Chair)
9:30-10:30	Review of Process for establishing methodology
10:30-12:00	Open Discussion
1:00-3:00	Review of methodology
3:00-5:00	Open Discussion

Day 2 – 29 October 2014

9:00-9:15	Logistics
9:15-10:45	Northeast Implementation
10:45-12:00	Open Discussion
1:00-2:00	Broader Application (Stakeholder POVs)
2:00-3:00	Open Discussion
3:00-5:00	Closed Panel Discussion

Day 3 – 30 October 2014

9:00-11:00	Closed Panel Writing
11:00-12:00	Panel Summary with POCs and NMFS Leadership
	Adjourn

Appendix 3: Panel Membership or other pertinent information from the panel review meeting.

The following attended the panel review meeting during October 28-30. The NFMS Users group only attended in the afternoon of October 29th.

CIE Panel Members

Dr. Nick Caputi	nick.caputi@fish.wa.gov.au
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Dr. Jeff Hutchings	jeff.hutchings@dal.ca

NFMS Chair

Dr. Anne Hollowed	anne.hollowed@noaa.gov

NFMS Vulnerability Assessment Team

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NFMS Users

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