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Proceedings of the Pacific regional peer review on the review of the model and information needed to identify Critical Habitat for Leatherback Turtle – Pacific Population

December 5-6, 2012
Nanaimo BC

Chairperson: Sean MacConnachie
Editor: Sean MacConnachie

Fisheries and Oceans Canada
Science Branch
3190 Hammond Bay Road
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Canada

Foreword

The purpose of these Proceedings is to document the activities and key discussions of the meeting. The Proceedings may include research recommendations, uncertainties, and the rationale for decisions made during the meeting. Proceedings may also document when data, analyses or interpretations were reviewed and rejected on scientific grounds, including the reason(s) for rejection. As such, interpretations and opinions presented in this report individually may be factually incorrect or misleading, but are included to record as faithfully as possible what was considered at the meeting. No statements are to be taken as reflecting the conclusions of the meeting unless they are clearly identified as such. Moreover, further review may result in a change of conclusions where additional information was identified as relevant to the topics being considered, but not available in the timeframe of the meeting. In the rare case when there are formal dissenting views, these are also archived as Annexes to the Proceedings.

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SUMMARY

These Proceedings summarize the relevant discussions and key conclusions that resulted from a Fisheries and Oceans Canada (DFO), Canadian Science Advisory Secretariat (CSAS) Regional Advisory meeting held on December 5th, 2012 at the Pacific Biological Station in Nanaimo, B.C. One working paper focusing on recommendations for critical habitat for Leatherback Sea Turtle (*Dermochelys coriacea*) was presented for peer review.

In-person and web-based participation included staff from DFO Science and Ecosystem Management branches, and external participants from the Province of BC, NOAA and independent scientists.

The conclusions and advice resulting from this review will be provided in the form of a Science Advisory Report (SAR) providing advice to the DFO species at risk program to inform the eventual identification of critical habitat for Leatherback Sea Turtles in Canadian Pacific waters.

The SAR and the supporting Research Document will be made publicly available on the Canadian Science Advisory Secretariat (CSAS) website.

Compte rendu de l'examen par les pairs de la Région du Pacifique du modèle et de l'information nécessaires pour désigner l'habitat essentiel de la tortue luth – Population du Pacifique

SOMMAIRE

Le présent compte rendu résume l'essentiel des discussions et les principales conclusions de la réunion régionale consultative de Pêches et Océans Canada (MPO) et du Secrétariat canadien de consultation scientifique (SCCS) qui a eu lieu le 5 décembre 2012 à la station biologique du Pacifique de Nanaimo, en Colombie-Britannique. On y présente un document de travail sur les recommandations concernant l'habitat essentiel de la tortue luth (*Dermochelys coriacea*) aux fins d'examen par les pairs.

Parmi les personnes qui ont pris part à la réunion en personne et par cyberconférence, on compte des employés des directions des sciences et de la gestion des écosystèmes du MPO, des participants externes de la province de la Colombie-Britannique et de la NOAA et des scientifiques indépendants.

Les conclusions et avis découlant de l'examen seront présentés sous forme d'avis scientifique destiné au programme des espèces en péril du MPO et visant à éclairer la désignation éventuelle de l'habitat essentiel des tortues luths vivant dans les eaux canadiennes du Pacifique.

L'avis scientifique et le document de recherche à l'appui seront rendus publics sur le site Web du Secrétariat canadien de consultation scientifique (SCCS).

INTRODUCTION

A Fisheries and Oceans Canada (DFO) Canadian Science Advisory Secretariat (CSAS), Regional Advisory Process (RAP) meeting was held on December 5th, 2012 at the Pacific Biological Station in Nanaimo to review recommendations on the identification of critical habitat for Leatherback Sea Turtle (*Dermochelys coriacea*).

The Terms of Reference (TOR) for the science review were developed in response to a request for advice from the Species at Risk program in the Fisheries and Aquaculture Management Branch of DFO. Notifications of the science review and conditions for participation were sent to representatives with relevant expertise from the Province of BC, US government agencies, independent scientists, environmental non-governmental organizations and academia.

The following working paper was prepared and made available to meeting participants prior to the meeting:

Gregr E.J., Gryba, R., James, M.C., Brotz, L. and Thornton, S.J. 2013. Information relevant to the identification of critical habitat for Leatherback Sea Turtles (*Demochelys coriacea*) in Pacific Canadian waters. CSAP Working Paper 2011/P54

The meeting Chair, Sean MacConnachie, welcomed participants, reviewed the role of CSAS in the provision of peer-reviewed advice, and gave a general overview of the CSAS process. The Chair discussed the role of participants, the purpose of the various RAP publications (Science Advisory Report, Proceedings and Research Document), and the definition and process around achieving consensus decisions and advice. Everyone was invited to participate fully in the discussion and to contribute knowledge to the process, with the goal of delivering scientifically defensible conclusions and advice. It was confirmed with participants that all had received copies of the TOR, and working paper.

The Chair reviewed the Agenda (Appendix A) and the TOR (Appendix C) for the meeting, highlighting the objectives and identifying the Rapporteur for the review. The Chair then reviewed the ground rules and process for exchange, reminding participants that the meeting was a science review and not a consultation. The room was equipped with microphones to allow remote participation by web-based attendees, and in-person attendees were reminded to address comments and questions so they could be heard by those online.

Participants were reminded that everyone at the meeting had equal standing and that they were expected to contribute to the review process if they had information or questions relevant to the paper being discussed. In total, 21 people participated in the RAP (Appendix B). Caroline Wells was identified as the Rapporteur for the meeting.

Participants were informed that two reviewers had been asked before the meeting to provide detailed written reviews for the working paper to assist everyone attending the peer-review meeting.

The conclusions and advice resulting from this review will be provided in the form of Science Advisory Report (SAR) to Fisheries and Aquaculture Management Branch to inform the identification of critical habitat for Leatherback Sea Turtle. The SAR and supporting Research Documents will be made publicly available on the CSAS website.

REVIEW

Working Paper: Information relevant to the identification of critical habitat for Leatherback Sea Turtles (*Demochelys coriacea*) in Canadian Pacific waters.

Rapporteur: Caroline Wells

Presenter: Ed Gregr

PRESENTATION OF WORKING PAPER

The author gave an overview presentation of the paper highlighting the approach they took to model probable areas of foraging for Leatherback Sea Turtles (LBT). There is relatively little presence data for LBT in Canadian Pacific waters. The authors have taken the approach of identifying areas where prey items would be dense enough to be deemed a feature for critical habitat. Using two variables, ocean current and Chlorophyll A levels, they were able to identify different areas that predicted where jellyfish were likely to concentrate. Jellyfish are the main prey items for LBT.

WRITTEN REVIEWS

First Review

The first reviewer thought the paper was well written and provided insight into foraging behaviour for a data limited species but identified some discrepancies that needed further discussion

The reviewer identified that using different resolutions for the environmental data in the predictive model may be inappropriate. The authors responded that using a value that is measured at a km^2 scale, e.g. for chlorophyll, was quite reasonable and that the models didn't suffer from down scaling chlorophyll. The broader resolution of currents and oceanographic data was used because the LBT distribution suggests that they occur away from the coast and that tidal currents would not have an effect as they would on more near shore species.

The reviewer recommended adding a sentence or two acknowledging that inshore currents are important but were not included because it would not provide more information. The authors agreed to this recommendation.

The reviewer questioned why the jellyfish energy analysis was included in the paper and further description of this topic would be helpful**.** The authors explained that the importance of foraging efficiency is looking at the caloric value of two primary jelly prey species. Further the description of the survey method would assist future researchers. A recommendation was made to remove this section from the paper and add it as an appendix as it provides valuable information.

The reviewer thought that the paper lacked sufficient description for which data were used and why. Further, there was not sufficient discussion on the assumption that the suitability of the habitat was linear to increasing chlorophyll and decreasing current speed. Finally there was insufficient description of why the sightings data was not used in the model and the precision issues associated with the sightings. The authors explained the shortcoming of the sightings dataset and there was very little evidence that the turtles were foraging at the time of being sighted but only transiting through the area. The inclusion of the sightings data shows that LBTs are present in Pacific waters and why an Area of Occupancy approach was not used to identify Critical Habitat. The reviewer recommended adding additional clarification/rationale of why sightings weren't used to validate the models and Critical Habitat identification in the report.

The reviewer also recommended that the threats from the ingestion of plastics and entanglement be separated into its own section.

Second review

This reviewer focused on those items not previously discussed in the initial review; specifically that the use of sea surface temperature (SST) in the modeling exercise. Based on his observations LBT tend to avoid areas where the SST is below 12°C. The authors responded that they did consider including SST as an environmental variable in the model but by placing restrictions on the temperature data that this may decrease the area of suitable foraging habitat for Critical Habitat (CH) identification. The authors utilized the precautionary approach in identifying as much CH as possible. Because the physical or physiological barrier that temperature may have on LBT in Canadian waters the authors chose not to use temperature in identifying CH. It was also thought that the other two environmental variables were sufficient to predict areas of high foraging suitability and including a SST value would not alter the result significantly.

A recommendation was made that the authors add more clarity why SST wasn't included in the model and what factors in the model would change if it was included.

The reviewer also suggested another means of validating the model would be extract the Chla and RMS values from an historic database that correspond to the date of the sightings and test the correspondence between observed and predicted. The authors responded that they did not have the capacity or time to try this. Further, the instantaneous position of any animal that is foraging is different than the habitat that is required for foraging.

GENERAL DISCUSSION

Following the reviewers' presentations and subsequent deliberations the chair opened the floor for general discussions.

Discussions focused on the portrayal of the different levels of suitable habitat that could be considered critical. The authors originally proposed three bins and used the Jenks classification system in the ESRI ArcGIS to identify the thresholds. The authors were encouraged to clarify why only three bins and reference the use of the Jenk's classification method. The rationale for only three bins was for simplicity. Unfortunately spatial thresholds to classify critical habitat from non-critical habitat have not been identified.

There were significant discussions regarding not using the sightings data (120) in the model. The authors responded that the model provided output based on the best available data.

A participant suggested that it is overstated to say that LBTs sightings are "infrequent" maybe better said as "rare". The department has conducted a lot of survey effort through cetacean surveys in BC (over 30,000 kms) and very few LBT have been observed. It appears that BC is at the northern end of the range of the species; could Canadian Pacific waters be considered marginal habitat, and it is reasonable to expect that there is critical habitat in marginal habitat? Conversely there is compelling evidence that the success of the population is closely tied to the energy that they get through foraging. These areas could be very important foraging habitat to the species. If the sightings data are used to validate our selection and the model shows foraging on the shelf maybe we just draw our polygon on the shelf? It would allow us to encompass the turtles that are between foraging areas and the turtles that are foraging. Further ships are a very poor platform to identify LBTs even in very dense areas of LBTs. It is suspected that LBTs are probably present in Canadian waters every year.

Regarding the variability in the sightings data, a participant noted that an average abundance estimate for California waters is 178 individuals annually. However, there is considerable variability throughout the years. A 5.9% per year decline in abundance has been observed, which should be proportional to the decline in Indonesia.

Questions arose around using jellyfish surveys to overlay observations and make recommendations of foraging habitats from where the jellies are present. Unfortunately, there is very little data on Jellyfish distribution and there is unlikely to be much data in the future.

Questions arose around the threats to critical habitat. There are many fishing fleets in the proposed areas; how does this roll out for management decisions? By defining CH, it may lead to future actions in things like may impact prey availability? However, other participants felt that there may be no management implications at all in terms of changes to fisheries regardless of the size of the polygon.

There were significant discussions around the portrayal of CH in the draft maps and the determination of the different thresholds proposed by the authors and the model. There is uncertainty with the Chlorophyll layer. The authors picked a band that is less sensitive to contamination. However, there is an energy bias because the ocean circulation model does not look at energy in the system. The inclusion of tidal energy might reduce the size of the area above the Fraser River.

A suggestion was made in using the sightings data to inform the identification of CH to shape the polygon, not to validate the model. We would remove the coastal inlets and draw the shelf line and use both data sets to validate the selection of the shelf.

It was observed that the model is not a statistical model, it is a mechanistic model that is based on empirical data and as such as much information should be used as possible, that is to say, all data sets should be used including the biological information regarding foraging. Further, we can assume that the areas are putative foraging areas. Is it fair to say LBTs are not foraging on their way to these areas? Although the sighting data are low and biased it's all that is available.

Discussions ensued regarding depth as a variable in the model. A recommendation was made to go back and look at depth to validate the sightings and also see how it impacts excluding the inlets from the analysis. It was noted that turtles are observed in the inlets in the Atlantic Canada. Ninety percent of the sightings in the Pacific are from 2000m depth contour to the coastline**.** Continental shelf is considered 200m, continental slope is 2000m. Deeper areas would capture many of the canyons and the upwelling features so 2000m is very reasonable. It was noted that the CH off the coast of Oregon and Washington is 2000m. It was agreed that the 2000m depth contour would be used to delineate that outer edge of the polygon.

A point was made that the authors were assuming that LBT eat sea nettle jellyfish and that they are feeding off of jellies on the WCVI; but we do know that there is *Cyanea* jellies near Haida Gwaii and we know LBTs are present there. A recommendation was made to take also include *Cyanea* and siphonophores as prey items.

A question rose that it would be interesting to see if specific years jump out of the sightings data set. It was responded that the sightings data were fairly random throughout time in coastal BC and that no emerging patterns on a temporal scale have been observed.

Regarding the uncertainties associated with the model**:** El Nino and La Nina patterns have not been incorporated into the model. The use of the observations from the sightings network themselves likely impacts the uncertainty of the model outputs. In a perfect world there would be sightings of LBTs with jellies in their mouths. However, when LBTs are observed we don't know if they are in a foraging area or if they are on their way to a foraging area and the sightings data

do not reflect behaviour. However, it shouldn't matter if the observation isn't reflecting foraging behaviour? If an animal can't get to a forage ground then it can't use it. The uncertainty in the observational sightings data is that we can't validate the model because it doesn't indicate to us whether they are foraging or not. Observational data is still important to mark a time and place. The uncertainty in the sightings is around the line of advice we are providing to determine the CH ID comes down to what is the function we are protecting; we are protecting the function of foraging and we are including the sightings data as a second line of evidence and we need to be really careful on separating those two concepts. A recommendation was made to add a sentence about specifying foraging behaviour.

Recommendation: Put all data on Jellyfish caloric data, methods and results into an appendix

Recommendation: Add more clarity to what is meant by Jellyfish (what species of Jellyfish) and what type of gelatinous prey is foraged

Recommendation: Compare time scales to El Nino and La Nina years

Recommendation: Overstated that LBTs sightings are "in frequent" maybe better said as "*rare"* to give more context

Recommendation: Ultimate conclusion was to look at CHL and RMS

Recommendation: Incorporate the sightings data into model.

RECOMMENDATIONS & ADVICE

Three lines of evidence support the recommendation that critical habitat for Leatherback Sea Turtles should consist of the Canadian Pacific continental shelf excluding the mainland inlets, river deltas and portions of the Strait of Georgia (based on modeled area of high forage suitability, observations, and turtle behaviour). The shelf is defined as being from the toe of the slope (2000m) shoreward excluding areas of low salinity or freshwater outflow.

The following are considerations for refining and delineating the proposed boundaries:

- Need to verify the species and density of jellyfish in modeled areas exist.
- Identify locations of foraging Leatherback Sea Turtles in Canadian waters as well as frequency of habitat use.
- Investigate relationship with foraging and transiting turtles and SST.
- A schedule of studies should be identified to refine the boundaries of critical habitat over time as more information becomes available.
- Resolving uncertainty of exclusion of near shore waters as potential critical habitat should be investigated.

ACKNOWLEDGEMENTS

The chair wishes to acknowledge and thank the authors for their hard work, and Scott Benson and Jessica Finney for their written reviews. Also, thanks to Nic Dedeluk of the CSAS office for coordinating and arranging meeting logistics and managing the webinar. Finally, thank you to Caroline Wells for being the Rapporteur.

APPENDIX A: AGENDA

Regional Peer Review Meeting (RPR)

Assessment of information regarding critical habitat for the Leatherback Turtle in British Columbia

December 5-6, 2012

Pacific Biological Station
Nanaimo, BC

Chairperson: Sean MacConnachie

DAY 1 - December 5, 2012

Time	Subject	Presenter
09:00	Introductions Review Agenda & Housekeeping CSAS Overview	Sean MacConnachie
09:15	Review of Terms of Reference	Sean MacConnachie & Participants
09:30	Presentation of Working Paper	Gregr and Thornton
10:30	***Break***	
10:45	Questions of Clarification	RAP Participants
11:15	Presentation of Reviews & Authors' Responses	Reviewers & Author(s)
12:00	***Lunch Break***	
13:00	Discussion and Building Agreement on Conclusions, Recommendations, Advice and Future Work	RAP Participants
17:00	***Adjournment***	

DAY 2 - December 6, 2012

Time	Subject	Presenter
09:00	Introductions Summary of Day 1 discussions	Sean MacConnachie
09:30	Clarification on outstanding issues	RAP Participants
10:30	***Break***	
11:00	Review of SAR and consensus on conclusions and recommendations	RAP Participants
12:00	***Lunch Break***	
13:00	Review of SAR and consensus on conclusions and recommendations (if needed)	RAP Participants
16:00	***Adjournment***	

APPENDIX B: PARTICIPANTS

Last Name	First Name	Affiliation
DFO		
Arai	Mary	DFO Science
Brown	Tom	SAFE
Curtis	Janelle	Salmon and Freshwater Ecosystems
Finney	Jessica	DFO Science
Ford	John	Stock Assessment
Francis	Kelly	DFO
James	Mike	DFO Science
Joyce	Marilyn	CSAP
MacConnachie	Sean	DFO Science
Nichol	Linda	Stock Assessment
Schweigert	Jake	STAD
Spaven	Lisa	FAM
Thornton	Sheila	SARA
Wells	Caroline	SARA
External		
Chalmers	Dennis	Province of BC
Brotz	Lucas	University of British Columbia
Benson	Scott	NOAA/NMFS
Wallace	Bryan	Oceanic Society
Tiwari	Majula	NOAA/NMFS
Gryba	Rowenna	University of British Columbia
Greg	Ed	SciTech Environmental Consulting

APPENDIX C: TERMS OF REFERENCE

Review of the model and information needed to identify Critical Habitat for Leatherback Turtle – Pacific Population

Pacific Regional Science Advisory Process

December 5, 2012
Nanaimo, BC

Chairperson: Sean MacConnachie

Context

Leatherback turtle – Pacific population (*Dermochelys coriacea*) was listed in 2003 as Endangered under the Species at Risk Act (SARA), and a recovery strategy for the species was completed in 2006 (Pacific Leatherback Turtle Recovery Team 2006). A recovery strategy or action plan must identify an endangered species' critical habitat, or "the habitat that is necessary for the survival or recovery of a listed species and that is identified as the species critical habitat in the recovery strategy or action plan for the species". Under SARA s41(1)(c) a species' critical habitat must be identified to the extent possible, based on the best available information.

DFO SARA Management Program has requested science advice in support of the identification of critical habitat and development of the Action Plan for the Leatherback turtle under SARA. A technical workshop was held in November 2011 to provide direction to the work necessary to complete this request. Given the paucity of observational data for this species in Pacific waters, an area of occupancy approach to recommending critical habitat has been deemed to be impractical. The authors will explore spatial modeling techniques using biological, physical and temporal variables to recommend critical habitat.

Objectives

The following working paper will be reviewed and provide the basis for discussion and advice:

Gregr E, Gryber R, James MC, Thornton SJ. 2012. Recommendations for the identification of critical habitat for the Leatherback Turtle – Pacific population (*Dermochelys coriacea*). CSAP Working Paper 2012/PXX

To provide the best available information regarding the geospatial extent and the biophysical attributes, features and functions of the habitat necessary for the survival or recovery of Leatherback Turtle in Canadian Pacific waters.

Expected publications

- CSAS Science Advisory Report (1)
- CSAS Research Document (1)
- CSAS Proceedings

Participation

- DFO Science, Ecosystem Management Branch, Species at Risk, Policy and Economics
- NOAA
- Non-governmental organizations
- Other Stakeholders

References Cited

Pacific Leatherback Turtle Recovery Team. 2006. Recovery Strategy for Leatherback Turtles (*Dermochelys coriacea*) in Pacific Canadian Waters. Species at Risk Act Recovery Strategy Series. Fisheries and Oceans Canada, Vancouver, v + 41 pp.

APPENDIX D: WORKING PAPER ABSTRACT

In 1981, Leatherback Sea Turtle populations in Canadian waters were assessed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) as Endangered. This status was confirmed in 2001, and in 2003, the Leatherback Sea Turtle was listed as Endangered on Schedule 1 of the *Species at Risk Act* (*SARA*). In May 2012, the species was reassessed as two separate populations (Atlantic and Pacific). Both populations continue to be designated as Endangered.

As part of the SARA recovery process, the “Recovery Strategy for the Leatherback Turtle populations in Pacific Canadian waters” was published on the *SARA* Registry in February 2007. For species listed as Threatened or Endangered, *SARA* also requires identification of the habitat necessary for the survival or recovery of a listed wildlife species. Once this habitat is identified in the final recovery strategy or action plan, it is deemed the species “critical habitat” and afforded legal protection from destruction under the *Act*. Leatherback Sea Turtles feed on scyphozoan prey in temperate high latitude locales, such as the Pacific Canadian coast. We used an envelope model to locate suitable habitat for Leatherback Sea Turtle foraging, and describe the biophysical function and features of suitable habitat in Canadian Pacific waters.

APPENDIX E: WRITTEN REVIEWS

REVIEWER: JESSICA FINNEY

Fisheries and Oceans Canada

Working Paper: Gregr E, Gryba R, James MC, Thornton SJ. Recommendations for the identification of critical habitat for the Leatherback Turtle – Pacific population (*Dermochelys coriacea*). CSAP Working Paper 2012/P67

The authors did an excellent job of pulling together information from numerous studies on leatherback turtles in both the Pacific and Atlantic Oceans. The objective of the analysis was clearly laid out, and the authors provide a reasonable estimation of critical habitat for leatherback sea turtles in Pacific Canadian waters. Below I have listed several comments and suggestions on the content of the paper.

Envelope Model

Leatherback turtle data

- The introduction has a few sentences on the sources of leatherback turtle sightings in British Columbia and the presumed biases associated with them. I think that it would be helpful to reiterate this information in the methods section, as these issues provide the rational for using an envelope model rather than another more complex model
- I find it interesting that there are so many offshore sightings of leatherback turtles, particularly in the area between Vancouver Island and Haida Gwaii. I would expect that there are fewer vessels in that area, and so would assume that there would be fewer opportunistic sightings. Can the authors comment on the origins of those sightings and the possible reason for there being so many there?

Environmental data

- The authors did a good job of rationalizing which environmental variables were used
- The scale of the modeling (100m x 100m) was somewhat surprising. Depth was the only layer that was available at this resolution, and it was ultimately excluded from the final model selected by the authors. The chlorophyll and current speed data were both originally at a much larger scale (1.2km and 10km respectively). Given the coarseness of the majority of the environmental data, and the wide-ranging behaviour of leatherback turtles, it may have been more appropriate to model at a coarser resolution.
- Was there a reason the HYCOM data was selected for modeling? Current speed modeling done by Mike Foreman at the Institute of Ocean Sciences is available in lower resolution, particularly in nearshore areas. His model does not have monthly values, but it does have summer values, which would probably be sufficient for this paper.

Model building

- The authors provided a reasonable rationale for using an envelope model instead of other methods (insufficient and biased sightings)
- Values of the quantile divisions of the environmental variables would be helpful, either in the figures or on a separate table
- It appears that the way the envelope model has been set up makes the assumption that there is a linear connection between current speed and chlorophyll and habitat suitability. I did not find evidence in the manuscript to support the assumption that increasingly lower

current speeds and increasingly higher chlorophyll concentration is linearly related to higher jellyfish concentrations. If there is evidence for such a linear relationship (rather than some other kind of relationship) in the literature, this needs to be clearly highlighted, as those assumptions seem to be the basis for this particular envelope model.

Envelope integration

- I do not think that sufficient evidence was provided to support selecting the Chla * RMS model over the others, especially without comparing the models' predictive success to the available leatherback sighting data. While the different models may differ in detail only, those details may be key in predicting critical habitat

Jellyfish Data

- The authors provided a good connection between leatherback reproductive success and availability of jellyfish, and between associating jellyfish with critical habitat
- The proposed method to gain more information on jellyfish distribution is a very valuable contribution of the paper. I like the step-wise approach, as it will encourage information to be gathered even when things on research vessels are very busy
- I am unclear on why the jellyfish energy analysis was included. One can make the assumption that it will eventually lead to a quantification of how many jellyfish are needed for foraging leatherbacks. However, there is a missing piece in the paper that links back to how jellyfish energy analysis relates to leatherback critical habitat, and it should be added
- It seems that there are some serious problems with how to determine caloric content of jellyfish at this point. Future work should resolve some of these issues. The work done here represents very small sample sizes, so limited conclusions can be made. Sample sizes should be increased in the future
- In section 1.2.2 on leatherback sea turtle prey the final paragraph discusses threats (plastic and entanglement). This is extremely valuable information, and perhaps it would be better situated in a separate section. Presumably these are some of the things that will need to be considered when managers decide on how to protect critical habitat, so they should be highlighted.

Model Validation

- I found it curious that in section 3.5 (Model Validation) the authors stated that finding a correlation between high densities of jellies and areas identified as having a high suitability of foraging leatherbacks would provide evidence of model validity. While this is true, actual sightings of leatherbacks would also provide some of this evidence. I agree that the sighting data are likely to be biased as they are opportunistic sightings, but they would provide some indication of how the models are performing. It appears that about half of the sightings do not fall within the area identified as suitable habitat, and that is somewhat concerning. It would be valuable to have some discussion about how the sightings line up with the models' predictions, and why there may be some discrepancies.

Discussion

- The authors' discussion on biophysical features and functions, and linking them back to critical habitat is very clearly laid out
- The authors provide a good explanation for why temperature may not be horribly important in the current modeling exercise

- In section 5.1 (Next Steps) the authors state that the predictive performance of various configurations of the individual envelope models, as well as the integrated model, can be compared using the opportunistic sighting data. I completely agree, and would like to see that done in this paper, as it is a key piece in selecting which model to use to identify critical habitat, and also provides an indication of how well the model is performing.

The authors have provided some valuable tools to improve our understanding of leatherback sea turtle critical habitat in Pacific Canadian waters. They have done an admirable job given the available data, and developed tools to help us improve predictions in the future.

REVIEWER: SCOTT BENSON

NOAA-NMFS-SWFSC

Working Paper: Gregr E, Gryba R, James MC, Thornton SJ. Recommendations for the identification of critical habitat for the Leatherback Turtle – Pacific population (*Dermochelys coriacea*). CSAP Working Paper 2012/P67

The authors presented a well-organized review of leatherback habitat from multiple sources and used the best available science to identify critical habitat in Pacific Canada waters. Below I have listed a few comments and suggestions on the content of the paper.

Introduction

Leatherback turtle population in Canada

- Page 8 (first paragraph): Although persistence has been 'maintained' at key nesting beaches in the western Pacific, recent analysis indicates that the population has experienced a severe decline at the largest nesting sites during the past 25 years and continues to decline at a steep (6%) rate (Tapilatu et al., 2013).
- The comment about longer nesting remigration intervals (last paragraph) is true when comparing remigration intervals of western Atlantic leatherbacks with those of the eastern Pacific population. The western Pacific population utilizes multiple foraging areas throughout the Pacific, therefore, remigration intervals are variable. The sentence implies that Pacific leatherbacks might be food-limited relative to Atlantic leatherbacks. The eastern Pacific population is thought to forage primarily in the pelagic southeast Pacific gyre environment. Western Pacific leatherbacks that forage in the northeast Pacific are primarily foraging in neritic waters where geomorphology of the coast create conditions that lead to relatively predictable high densities of gelatinous prey.

Features associated with Leatherback Foraging habitat

- Should mention that foraging behavior also occurs off the coasts of Oregon and Washington. Both foraging areas have been designated as 'critical habitat' for leatherback turtles. Although prey selection in OR/WA waters is unknown, large densities of C. fuscescens were encountered at leatherback sighting locations in neritc waters.

LEATHERBACK FORAGING MODEL

- Overall, I was pleased and impressed by the approach and results from the envelope model. Nevertheless, despite the associated biases with the leatherback sightings, I think it would be worthwhile to consider leatherback presence with remotely sensed data…as a potential means of verification. Correlational analysis of remotely sensed data with the leatherback sighting database (or future jelly data) can be facilitated with data accessed from CoastWatch Browser.

2.2.3 Depth

- Large scyphomedusae are most likely to be found in neritic waters. Although there is a probability that a significant proportion of scyphomedusae could be advected offshore into deeper waters, other gelatinous zooplankton are regularly found in offshore waters (i.e. salps, pyrosomes, etc.). Leatherbacks consume a diverse assemblage of gelatinous zooplankton, therefore, it's possible that offshore foraging patches are comprised of gelatinous zooplankton species that are not scyphomedusae. Unfortunately, identification of offshore prey species is difficult to determine and spatio-temporal patterns of gelatinous zooplankton densities seem ephemeral.

2.2.4 Chlorophyll-a

- A 'threshold' chlorophyll value was not identified in Benson et al. 2011. A mean value was indentified.

3.1 JELLYFISH ENERGY ASSESSMENT

- The bell diameters of *Chrysaora fuscescens* in Table 2 are small relative to what we've sampled in California waters. It has been documented that bell diameters of *C. fuscescens* increase from May – October. We also see evidence of senescence during late fall. The jellies in Table 2 were collected in late October. It would be interesting to know more about the seasonal variability of bell diameters in Pacific Canadian waters. If 143 – 231 mm is the maximum, densities would need to be very great to support leatherback metabolic requirements.

4.2 THE HABITAT MODEL

- Regarding effect of SST:
    - I understand the rationale behind not using SST in the model, and the present model works well, in my opinion, however, SST may have a role on predicting the presence of leatherback turtles. First, several aquariums have learned that *Chrysaora fuscescens* and other gelatinous species are sensitive to temperature variability. Second, although leatherbacks have a wide thermal niche and have been encountered occasionally in very cold waters at high latitude locations (rare events), leatherbacks do not commonly exploit the world's coldest oceans or venture into very cold water. Occupation of North American west coast waters by leatherbacks is characterized by seasonal peaks corresponding to seasonally elevated SST's. Because the model is temporally constrained to the months of June to October, the major seasonal effect of SST variability on leatherback turtle presence is absent, however, I'd still expect SST variability to contribute to the spatio-temporal patterns of leatherback presence within the areas considered. If refinement of the model is desired, I'd suggest incorporating SST.

Overall, I was impressed with the approach and logic applied to generate the model and with the model output. Future investigations might also be targeted to learn the role of habitat variability on jellyfish development (polyp-to-strobulation) and residence of leatherback turtles within a season (June – October). In California waters, we've seen leatherbacks avoid areas with cooler isotherms, or move away from an area with high jelly densities once SST drops below 13^{o} C.

Ultimately, you need a means of verifying or evaluating the model. One means of evaluating the model would be to extract remotely sensed environmental data from recorded sightings to learn how well those data would correspond to the developed model.