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Pacific Region

Proceedings of the Pacific regional peer review on the Pre-COSEWIC Assessment for Northern Abalone

September 26-27, 2019
Nanaimo, British Columbia

Chairperson: Nicholas Komick
Editors: Amy Ganton, Nicholas Komick

Fisheries and Oceans Canada
Science Branch
3190 Hammond Bay Road
Nanaimo, BC V9T 6N7

October 2020

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 Peer Review meeting on September 26–27, 2019 at the Pacific Biological Station in Nanaimo, B.C. A working paper focusing on reviewing existing DFO information relevant to the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) status assessment for Northern Abalone in Canadian waters was presented for peer review.

In-person and web-based participation included Fisheries and Oceans Canada (DFO) Science and Fisheries and Aquatic Management Sectors staff; and external participants from First Nations organizations, COSEWIC, and the Washington Department of Fish and Wildlife.

The conclusions resulting from this review will be provided in the form of Research Document providing information to COSEWIC to inform the status assessment of Northern Abalone.

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

INTRODUCTION

A Fisheries and Oceans Canada (DFO) Canadian Science Advisory Secretariat (CSAS), Regional Peer Review (RPR) meeting was held on September 26–27, 2019 at the Pacific Biological Station in Nanaimo to review the existing DFO information relevant to the (Committee on the Status of Endangered Wildlife in Canada) COSEWIC status assessment for Northern Abalone in Canadian waters.

The Terms of Reference (TOR) for the science review (Appendix A) were developed in response to a request for an updated report on the best available DFO information to support COSEWIC. Notifications of the science review and conditions for participation were sent to representatives with relevant expertise from within DFO Science, DFO Resource Management, First Nations, Washington Department of Fish and Wildlife, and COSEWIC.

The following working paper (WP) was prepared and made available to participants prior to the meeting (working paper abstract provided in Appendix B):

> Obradovich, S.G., Hansen, S.C., Zhang, Z., MacNeill, S., Nichol, L.M., Rooper, C.N, St. Germain, C., Waddell, B.J., and Barton, L.L. 2019. Pre-COSEWIC review of Northern Abalone (*Haliotis kamtschatkana*) along the Pacific Coast of Canada. CSAP Working Paper 2017SAR04.

The meeting Chair, Nicholas Komick, 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 pre-COSEWIC report, 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 WP.

The Chair reviewed the Agenda (Appendix C) and the TOR for the meeting, highlighting the objectives and identifying the Rapporteur for the process. 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.

Members were reminded that everyone at the meeting had equal standing as participants 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, 31 people participated in the RPR (Appendix D). Amy Ganton was identified as the Rapporteur for the meeting.

Participants were informed that Henry Carson and Luke Rogers had been asked before the meeting to provide detailed written reviews for the working paper to assist everyone attending the peer-review meeting (Appendix E). Participants were provided with copies of the written reviews.

The conclusions and advice resulting from this review will be provided in the form of a Research Document to COSEWIC to inform the next assessment of Northern Abalone in Canadian waters. The Research Document and Proceedings will be made publicly available on the Canadian Science Advisory Secretariat (CSAS) website.

REVIEW

Working Paper:	Obradovich, S.G., Hansen, S.C., Zhang, Z., MacNeill, S., Nichol, L.M., Rooper, C.N, St. Germain, C., Waddell, B.J., and Barton, L.L. 2019. Pre-COSEWIC review of Northern Abalone (*Haliotis kamtschatkana*) along the Pacific Coast of Canada. CSAP Working Paper 2017SAR04.
Rapporteur:	Amy Ganton
Presenter(s):	Christine Hansen, Zane Zhang

PRESENTATION OF WORKING PAPER

The following authors were present: S.C. Hansen, Z. Zhang, S. MacNeill, L.M. Nichol, C.N. Rooper, C. St. Germain, B.J. Waddell, L.L. Barton, and D.L. Curtis. It was agreed that D.L. Curtis be added as an author to the paper. An oral presentation was given by Christine Hansen and Zane Zhang to summarize the working paper described by the abstract within Appendix B.

PRESENTATION OF WRITTEN REVIEWS

HENRY CARSON

Please refer to Appendix E for the full written review. The main comments are listed below:

- It would be helpful to provide clarification to the reader about what was considered a covariate in the GAM model in Section 5 (Population Trends).
- Additional information about historical removals from Southern and Northern BC populations would provide context to the reader.
- Some references require modification.

AUTHORS' RESPONSE TO HENRY CARSON

The authors will provide additional information about the Georgia Basin to describe low densities, and observations from fishery logs relative to the total historical harvest of Northern Abalone. In addition, the authors will add information about the covariates that were used, time frames considered, and significance letters that are currently in an in-press technical report but not in the WP. Although a separate analysis could be completed that blocked covariates that could not be separated, it would be outside of the scope of the TOR and better suited to a future research section of the WP.

LUKE ROGERS

Please refer to Appendix E for the full written review. The main comments are listed below:

- Clarification is needed on the intended scope of the information and the rationale for the WP. It should be clear to the reader that the WP is an update of information based on the previous COSEWIC report.
- A new modeling methods is available that could be used in the convergence diagnostic in the Bayesian Hurdle Model. In addition, a multi-level model could be explored to use all available data in new parameter estimates.

- Suggestions for layout to present the information in a more concise, streamlined manner through tables of surveys, studies and sources of data. In addition, providing clarification on intended meanings for values, key words, and aspects like stock-recruit relationships.

AUTHORS' RESPONSE TO LUKE ROGERS

The authors will add language to the document to clarify the scope, intended meanings, and tables to condense information. The diagnostic method used in the paper is a standard method used by DFO for this type of analysis. The authors were familiar with the method, and with time limitations for the WP, additional analysis cannot be performed. Although a multi-level model could be implemented, the existing parameter estimates must be used to align with the previous COSEWIC report.

GENERAL DISCUSSION

The scope of information included in the WP and how it was represented in the document and title was discussed at length. While it was understood that the TOR and intent of a pre-COSEWIC report as part of a CSAS process were to summarize the best available information from DFO, further clarification was requested for external audiences to ensure the audience did not assume the WP provided a review of all information available. In addition, the purpose of the document and the role of DFO in the COSEWIC process was discussed. While the purpose was to present the best available information about the stock and not to provide recommendations to COSEWIC, the Committee recognized the need for additional text in the WP that interpreted the results of the trends observed from the model outputs. The Committee agreed to amend the WP to reflect the scope of information and to expand on model outputs.

Uncertainties within the model, how they were accounted for, and how they were communicated to the audience were debated by the Committee. In some instances, elements like poaching introduced uncertainties that could not be incorporated into models because the scale was unknown. The Committee suggested additional information be added to address the uncertainties.

The relationship of Sea Otters as predators to abalone were discussed extensively and questions arose around how specific elements of the relationship were included in the WP. For example, the changes in abalone behavior in response to predation from sea otters over time, and that the model uses mortality rates based on the size of abalone but the size may change when Sea Otters are present. The authors agreed to include more information about the impact of Sea Otters in the WP.

Finally, the Committee discussed the need for continued collaboration with communities to publish data, which may be included in future analyses by DFO.

CONCLUSIONS

There was no dissent on the WP by the Committee and the paper was accepted. The authors would make minor revisions based on the feedback provided by the Committee during the meeting, and the revisions would not change the outcomes or direction of the WP.

RECOMMENDATIONS

Recommendations are provided through the Research Document.

ACKNOWLEDGEMENTS

We appreciate the time contributed to the CSAS process by all participants. In particular, we thank the reviewers, Henry Carson and Luke Rogers, for their time and expertise.

APPENDIX A: TERMS OF REFERENCE

Pre-COSEWIC Assessment for Northern Abalone

Regional Peer Review Meeting

September 26-27, 2019
Nanaimo, British Columbia

Chairperson: Nicholas Komick

Context

The implementation of the federal *Species at Risk Act* (SARA), proclaimed in June 2003, begins with an assessment of a species' risk of extinction by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). COSEWIC is a non-government scientific advisory body that has been established under Section 14(1) of SARA to perform species assessments, which provide the scientific foundation for listing species under SARA. Therefore, an assessment initiates the regulatory process whereby the competent Minister must decide whether to accept COSEWIC's assessment and add a species to Schedule 1 of SARA, which would result in legal protection for the species under the Act. If the species is already on Schedule 1 of SARA, the Minister may decide to keep the species on the list, reclassify it as per the COSEWIC assessment, or to remove it from the list (Section 27 of SARA).

Fisheries and Oceans Canada (DFO), as a generator and archivist of information on marine species and some freshwater species, is to provide COSEWIC with the best information available to ensure that an accurate assessment of the status of a species can be undertaken.

The Northern Abalone (*Haliotis kamtschatkana*) was listed on COSEWIC's Fall 2018 Call for Bids to produce a status report, with the following justification:

Northern Abalone, a marine mollusc, are patchily distributed along the Pacific Coast of Canada and were harvested until a moratorium was put in place in 1990. Designated as Threatened in 1999 and again in 2001, Northern Abalone were last assessed and designated as Endangered in 2009, with a large decline in the mature portion of the population (88-89% between 1978 and 2007) (COSEWIC 2009). Population size was estimated at 420,000 individuals, with the extent of occurrence in Canada calculated as 207,478 km^2 (COSEWIC 2009). Poaching has been identified as the biggest threat to Northern Abalone, and predation from the recovering Sea Otter population, along with low Northern Abalone spawner densities potentially reducing successful recruitment (the Allee effect) may further impact Northern Abalone abundance.

Objectives

The overall objective of this meeting is to peer-review DFO existing information relevant to the COSEWIC status assessment for Northern Abalone in Canadian waters, considering data related to the status and trends of, and threats to this species inside and outside of Canadian waters, and the strengths and limitations of the information. This information will be available to COSEWIC, the authors of the species status report, and the co-chairs of the applicable COSEWIC Species Specialist Subcommittee. Publications from the peer-review meeting (see below) will be posted on the CSAS website.

Specifically, DFO information relevant to the following will be reviewed to the extent possible:

1) Life history characteristics

- Growth parameters: age and/or length at maturity, maximum age and/or length
- Total and natural mortality rates and recruitment rates (if data are available)
- Fecundity
- Generation time
- Early life history patterns
- Specialised niche or habitat requirements

2) Review of designatable units

Available information on population differentiation, which could support a COSEWIC decision of which populations below the species' level would be suitable for assessment and designation, will be reviewed. Information on morphology, meristics, genetics and distribution will be considered and discussed.

See COSEWIC Guidelines for recognizing designatable units.

3) Review the COSEWIC criteria for the species in Canada as a whole, and for each designatable units identified, if any. See Wildlife Species Assessment: COSEWIC Assessment Process, Categories and Guidelines.

COSEWIC Criterion – Declining Total Population

a. Summarize overall trends in population size (both number of mature individuals and total numbers in the population) over as long a period as possible and in particular for the past three generations (taken as mean age of parents). Additionally, present data on a scale appropriate to the data to clarify the rate of decline.

b. Identify threats to abundance— where declines have occurred over the past three generations, summarize the degree to which the causes of the declines are understood, and the evidence that the declines are a result of natural variability, habitat loss, fishing, or other human activity.

c. Where declines have occurred over the past three generations, summarize the evidence that the declines have ceased, are reversible, and the likely time scales for reversibility.

COSEWIC Criterion – Small Distribution and Decline or Fluctuation: for the species in Canada as a whole, and for designatable units identified, using information in the most recent assessments:

a. Summarise the current extent of occurrence (in km^2) in Canadian waters

b. Summarise the current area of occupancy (in km^2) in Canadian waters

c. Summarise changes in extent of occurrence and area of occupancy over as long a time as possible, and in particular, over the past three generations.

d. Summarise any evidence that there have been changes in the degree of fragmentation of the overall population, or a reduction in the number of meta-population units.

e. Summarise the proportion of the population that resides in Canadian waters, migration patterns (if any), and known breeding areas.

COSEWIC Criterion – Small Total Population Size and Decline and Very Small and Restricted: for the species in Canada as a whole, and for designatable units identified, using information in the most recent assessments:

a. Tabulate the best scientific estimates of the number of mature individuals;

b. If there are likely to be fewer than 10,000 mature individuals, summarize trends in numbers of mature individuals over the past 10 years or three generations, and, to the extent possible, causes for the trends.

Summarise the options for combining indicators to provide an assessment of status, and the caveats and uncertainties associated with each option.

For transboundary stocks, summarise the status of the population(s) outside of Canadian waters. State whether rescue from outside populations is likely.

4) Describe the characteristics or elements of the species habitat to the extent possible, and threats to that habitat

Habitat is defined as “in respect of aquatic species, spawning grounds and nursery, rearing, food supply, migration and any other areas on which aquatic species depend directly or indirectly in order to carry out their life processes, or areas where aquatic species formerly occurred and have the potential to be reintroduced”.

The phrasing of the following guidelines would be adapted to each specific species and some could be dropped on a case-by-case basis if considered *biologically* irrelevant. However, these questions should be posed even in cases when relatively little information is expected to be available, to ensure that every effort is made to consolidate whatever knowledge and information does exist on an aquatic species’ habitat requirements, and made available to COSEWIC.

a. Describe the functional properties that a species’ aquatic habitat must have to allow successful completion of all life history stages.

   In the best cases, the functional properties will include both features of the habitat occupied by the species and the mechanisms by which those habitat features play a role in the survivorship or fecundity of the species. However, in many cases the functional properties cannot be described beyond reporting patterns of distribution observed (or expected) in data sources, and general types of habitat feature known to be present in the area(s) of occurrence and suspected to have functional properties. Information will rarely be equally available for all life history stages of an aquatic species, and even distributional information may be missing for some stages. Science advice needs to be carefully worded in this regard to clearly communicate uncertainties and knowledge gaps.

b. Provide information on the spatial extent of the areas that are likely to have functional properties.

   Where geo-referenced data on habitat features are readily available, these data could be used to map and roughly quantify the locations and extent of the species’ habitat. Generally however, it should be sufficient to provide narrative information on what is known of the extent of occurrence of the types of habitats identified. Identify the activities most likely to threaten the functional properties, and provide information on the extent and consequences of those activities.

   COSEWIC’s operational guidelines require consideration of both the imminence of each

identified threat, and the strength of evidence that the threat actually does cause harm to the species or its habitat. The information and advice from the Pre-COSEWIC review should provide whatever information is available on both of those points. In addition, the information and advice should include at least a narrative discussion of the magnitude of impact caused by each identified threat when it does occur.

c. Recommend research or analysis activities that are necessary.

   Usually the work on the other Guidelines will identify many knowledge gaps.

   Recommendations made and enacted at this stage in the overall process could result in much more information being available should a Recovery Potential Assessment be required for the species.

5) Describe to the extent possible whether the species has a residence as defined by SARA

SARA s. 2(1) defines Residence as “a dwelling-place, such as a den, nest or other similar area or place, that is occupied or habitually occupied by one or more individuals during all or part of their life cycles, including breeding, rearing, staging, wintering, feeding or hibernating.”

6) Threats

A threat is any activity or process (both natural and anthropogenic) that has caused, is causing, or may cause harm, death, or behavioural changes to a species at risk or the destruction, degradation, and/or impairment of its habitat to the extent that population-level effects occur. See Threats and Limiting Factors section of the Instructions for the Preparation of COSEWIC Status Reports.

List and describe threats to the species considering:

- Threats need to pose serious or irreversible damage to the species. It is important to determine the magnitude (severity), extent (spatial), frequency (temporal) and causal certainty of each threat.
- Naturally limiting factors, such as aging, disease and/or predation that limit the distribution and/or abundance of a species are not normally considered threats unless they are altered by human activity or may pose a threat to a critically small or isolated population.
- Distinction should be made between general threats (e.g. agriculture) and specific threats (e.g. siltation from tile drains), which are caused by general activities.
- The causal certainty of each threat must be assessed and explicitly stated as threats identified may be based on hypothesis testing (lab or field), observation, expert opinion or speculation.

7) Manipulated Populations

An increasing number of wildlife species have seen their distribution or genetic make-up manipulated by humans, deliberately or accidentally. COSEWIC has developed guidelines to help determine the eligibility of populations for inclusion in wildlife species status assessments. Information available to DFO should be provided to facilitate such determination. See COSEWIC Guidelines on Manipulated Populations.

8) Other

Finally, as time allows, review status and trends in other indicators that would be relevant to evaluating the risk of extinction of the species. This includes the likelihood of imminent or

continuing decline in the abundance or distribution of the species, or that would otherwise be of value in preparation of COSEWIC Status Reports.

Working Paper

Obradovich, S.G., Hansen, S.C., Zhang, Z., MacNeill, S., Nichol, L.M., Rooper, C.N, St. Germain, C., Waddell, B.J., and Barton, L.L. 2019. Pre-COSEWIC review of Northern Abalone (*Haliotis kamtschatkana*) along the Pacific Coast of Canada. CSAP Working Paper 2017SAR04.

Expected Publications

- Proceedings
- Research Document

Participation

Participation is expected from:

- DFO Science, Fisheries Management (Species at Risk Program)
- COSEWIC status report author
- Members of COSEWIC (Co-Chairs and/or SSC experts)
- First Nations

References Cited

COSEWIC. 2009. COSEWIC assessment and update status report on the Northern Abalone *Haliotis kamtschatkana* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vii + 48 pp.

Curtis, D.L. and Zhang, Z. 2018. Northern Abalone, *Haliotis kamtschatkana*, stock status and re-analysis of index site surveys in British Columbia, 2000-2016. Can. Man. Rep. Fish. Aquat. Sci 3162 vi + 161 pp.

Lessard, J., Campbell, A., Zhang, Z., MacDougall, L., and Hankewich, S. 2007. Recovery Potential Assessment for the Northern Abalone (*Haliotis kamtschatkana*) in Canada. DFO Can. Sci. Advis. Res. Doc. 2007/061. 101 pp.

Fisheries and Oceans Canada. 2012. Action Plan for the Northern Abalone (*Haliotis kamtschatkana*) in Canada. *Species at Risk Act* Action Plan Series. Fisheries and Oceans Canada, Ottawa. vii + 65 pp.

APPENDIX B: ABSTRACT OF WORKING PAPER

This review presents data on Northern Abalone (*Haliotis kamtschatkana*) for use in a Committee on the Status of Endangered Wildlife in Canada (COSEWIC) status report. Northern Abalone were first designated as “Threatened” in 1999 by COSEWIC and re-designated as “Endangered” in 2009. Northern Abalone occur from Salisbury Sound, Alaska to Bahía Tortugas, Baja California. Genetic studies show no evidence for more than one population of Northern Abalone in BC. Adults generally occupy exposed and semi-exposed coastal waters of less than 10 m depth, but have been observed from the low intertidal zone to 40 m depth. The extent of occurrence in BC waters was estimated at 6,985 km^2 based on a recently developed habitat suitability index model. The largest recorded shell length for a Northern Abalone in BC is 165 mm. Northern Abalone reach 50 mm in 2-5 years and 100 mm in 6-9 years. Fifty percent of individuals are sexually mature around 50 mm and 100% at 70 mm. Estimated total mortality (0.19 – 0.49), varied by region and with the presence/absence of sea otters (*Enhydra lutris*). All fisheries for Northern Abalone have been closed since 1990, including commercial, recreational, and First Nations’, but illegal harvest continues to be a major concern for this species. Time series based on the DFO Northern Abalone Index Site Surveys show that estimated Northern Abalone densities have declined since the start of the time series (1978 in Northern BC), but have shown recent large increases in juvenile (shell length ≥ 20 mm to < 70 mm) densities and small increases in adult (≥70 mm) densities in Northern BC. However, the survey is marked by high variability in observed and estimated densities. Patterns are less clear in Southern BC where densities are much lower and have not shown large increases any size category. Densities from a repeated transect survey near Kitkatla, BC, in 2000 and 2016, show similar trends to the densities estimated from the DFO Northern Abalone Index Site Surveys in Northern BC.

APPENDIX C: AGENDA

Canadian Science Advisory Secretariat

Centre for Science Advice Pacific

Regional Peer Review Meeting (RPR)

Pre-COSEWIC Assessment for Northern Abalone

September 26-27, 2019

Nanaimo, BC

Chair: Nicholas Komick

DAY 1 – Thursday, September 26

Time	Subject	Presenter
0900	Introductions Review Agenda & Housekeeping CSAS Overview and Procedures	Chair
0915	Review Terms of Reference	Chair
0930	Presentation of Working Paper	Authors
1030	***Break***	
1050	Overview Written Reviews	Chair + Reviewers & Authors
12:00	***Lunch Break***	
1300	Identification of Key Issues for Group Discussion	Group
1330	Discussion & Resolution of Technical Issues	RPR Participants
1445	***Break***	
1500	Discussion & Resolution of Results & Conclusions	RPR Participants
1700	Adjourn for the Day	

Day 2 – Friday September 27

Time	Subject	Presenter
0900	Introductions Review Agenda & Housekeeping Review Status of Day 1	Chair
0915	Carry forward outstanding issues from Day 1 (*as necessary)*	RPR Participants
1000	Develop Consensus on Paper Acceptability & Agreed-upon Revisions	RPR Participants
1030	***Break***	
1050	*Continue* - Develop Consensus on Paper Acceptability & Agreed-upon Revisions	RPR Participants
1130	Next Steps – Chair to review • Research Document & Proceedings timelines • Other follow-up or commitments (*as necessary)*	Chair
1145	Other Business arising from the review	Chair & Participants
1200	***Adjourn meeting***	

APPENDIX D: PARTICIPANTS

Last Name	First Name	Affiliation
Barton	Leslie	DFO Science, Fishery & Assessment Data
Benoit	Dan	COSEWIC
Bureau	Dominique	DFO Science, Marine Invertebrates
Candy	John	DFO Science, Centre for Science Advice Pacific
Carson	Henry	Washington Department of Fish and Wildlife
Christensen	Lisa	DFO Science, Centre for Science Advice Pacific
Convey	Laurie	DFO Resource Management
Curtis	Dan	DFO Science, Marine Invertebrates
Edwards	Andy	DFO Science, Stock Assessment and Research
Fong	Ken	DFO Science, Marine Invertebrates
Foster	Sophie	DFO Science, Species At Risk
Ganton	Amy	DFO Science, Marine Invertebrates
Goulet	Gloria	COSEWIC
Govender	Rhona	DFO Resource Management, Species at Risk
Grant	Paul	DFO Science, Species At Risk
Hajas	Wayne	DFO Science, Stock Assessment and Research
Hankewich	Sandie	Kitasoo First Nation
Hansen	Christine	DFO Science, Marine Invertebrates
Komick	Nicholas	DFO Science, Salmon Assessment
Lee	Lynn	COSEWIC author
Lessard	Joanne	DFO Science, Ecosystems Science
Lochead	Janet	DFO Science, Marine Invertebrates
MacNeill	Shaun	DFO Science, Marine Invertebrates
Nichol	Linda	DFO Science, Marine Mammals
Rogers	Luke	DFO Science, Simon Fraser University
Rooper	Chris	DFO Science, Quantitative Assessment
Sowul	Kathleen	Washington Dept. Fish and Wildlife
Waddell	Brenda	DFO Science, Alumnus
White	Penny	Metlakatla First Nation
Winbourne	Janet	Contractor
Zhang	Zane	DFO Science, Quantitative Assessment

APPENDIX E: WORKING PAPER REVIEWS

HENRY CARSON, WASHINGTON DEPARTMENT OF FISH AND WILDLIFE

The following six questions provide general guidance for your review:

1. **Is the purpose of the working paper clearly stated?** Section 1.1 clearly states the purpose of the working paper.
2. **Are the data and methods adequate to support the conclusions?** Yes. The conclusions are mostly descriptions of the data trends, and do not stray far beyond that.
3. **Are the data and methods explained in sufficient detail to properly evaluate the conclusions?** In most cases, yes. I have included minor notes below, and note that some key references are to an in press paper that is not yet available.
4. **If the document presents advice to decision-makers, are the recommendations provided in a useable form?** I did not detect advice to decision-makers in the document.
5. **If the document presents advice to decision-makers does the advice reflect the uncertainty in the data, analysis or process?** I did not detect advice to decision-makers in the document.
6. **Can you suggest additional areas of research that are needed to improve our assessment abilities?** Making the very difficult link between observed densities and available habitat area would be useful. The paper makes some estimates of habitat area but declines to estimate population size based on those estimates, probably because of uncertainty in the specific habitat requirements.

Minor Notes:

Abstract – I'd move the last sentence up a bit to the Northern BC section. As it stands now it seems to be referring to Southern BC and contradicting the sentence before it.

Page 3 – Curiosity question – Did you *force* the t_0 parameter in the von Bertalanffy growth equation to be zero, or did you *assume* it was zero because the calculated parameter was some negative value (that has no biological meaning)?

Page 5 – I assume not a lot of length-weight data exist because surveyors prefer to count and measure shell lengths *in situ* without stressing or harming the animals by removing them to take weights. Could be worth mentioning that here for general understanding.

Page 9 – Our recent paper (cited elsewhere) discusses some data on size vs. cryptic behaviour and the proportion of populations likely detected during surveys.

Page 12 (and Appendix A) – Let me check if I am understanding the hypothesis for why estimated mortality rates have increased recently in the East Coast Haida Gwaii (ECHG) region. A recent recruitment pulse (of juveniles) has shifted the overall size distributions, which diverges from the predicted size distribution based on previous age distributions plus growth? So you are suggesting that "actual" loss of adults has probably not increased? I assume there is not other (anecdotal) evidence of an "actual" increase in mortality (otter foraging patterns, for instance)?

Page 18 – If possible an advanced copy of Hansen et al. in press would be useful to evaluate / understand the methods used.

Page 19 – What other terms besides year were considered as covariates in the GAM model? It might be useful to mention some key ones here, even if the complete description is in the appendix. Since year is confounded with region (I assume this is because of the rotational

survey schedule but it would probably be good to remind the reader of this here) could survey years be grouped into blocks (e.g. regions A,B, and C were surveyed in 2000, 2001,and 2002) for analysis? I guess this depends on what your environmental variables are – according to Appendix D some of them are unlikely to vary on 3-year timescales (bathymetry, average current speed) while others of course would (salinity).

Page 25 – The paragraph describing the historic abundance of abalone in Southern BC is a bit confusing. Are you suggesting that Georgia Basin never had abundant aggregations? The aggregations that were noted and subsequently disappeared – is that ostensibly due to fishing or are you suggesting they were ephemeral in nature? Perhaps some scale of the pounds removed would be useful – it's clear that the Northern BC fishery was much larger, but weren't a significant number of individuals removed from the Georgia Basin as well? The San Juan Islands recreational fishery was estimated to be 40,000 individuals removed per year at the peak.

Page 28 – "A large range of sizes are present in seizures of illegally harvested Northern Abalone, with 2-42% smaller than 100 mm shell length, which was the former legal size in the commercial fishery prior to its closure". I assume you mean minimum legal size.

Page 31 – "Carson (2019) reported that two populations of Northern Abalone with average densities of 0.17 and 0.25 Abalone/m^2 are self-sustaining, but have spawning aggregations at much higher densities (up to 1.2 Abalone/m^2)." I got this from unpublished Alaska Fish and Game data – I'm not sure it's appropriate to cite this to me as if I collected the data. I could confirm that you have permission to cite as Alaska Fish and Game unpublished if you want.

Page 33 – "For example, early life stages of the kelp *Nereocystis leutkeana*, an important habitat former and food source, may not persist at temperatures above 17 C (Vadas 1972, Carson 2019)." I'd remove the reference to us here, since all we did was cite Vadas for the same statement.

References – The WA status report should be Carson H.S. and Ulrich M. – and cited in the text as Carson and Ulrich 2019 instead of Carson 2019. I think in general there may be confusion about citations to the status review (Carson and Ulrich 2019) and the journal publication (Carson et al. 2019). I can help you sort which statement should reference which document if you want.

Appendix C – "A full description of the [North Central Coast] NCC [Habitat Suitability Index] HSI model for Northern Abalone can be found in Appendix B or Nephin et al. (In press)." I assume you mean Appendix B OF Nephin et al., instead of OR.

LUKE ROGERS, FISHERIES AND OCEANS CANADA

Thank you for the opportunity to review this Pre-COSEWIC Working Paper. The working paper delivers an extensive summary of Northern Abalone information and data sources consistent with the stated purpose. However, the presentation of methods and results is not always clear. Improvements can be made to refine the text and draw the focus nearer to the Terms of Reference. I therefore conclude that the objectives of the Working Paper as set out in the Terms of Reference are not yet met. I offer the following comments as suggestions to (1) improve the communication of key information and (2) increase the rigour of the analyses presented.

My comments are organized by section.

GENERAL COMMENTS

1. I think it may help to clarify the scope of the information to present. I noticed three types: citations to other studies / reviews, summaries of other studies / reviews, and new analyses.

I believe the working paper will be most effective when the relevant information from other studies / reviews is summarized thoroughly in the main text; when citations to major reviews appear both in the main text and in clear descriptive tables; and when new analyses draw on all available data to supersede previous results. There are opportunities to improve this balance throughout.

2. I found it difficult to understand at a glance which results were new, and which were reported from previous studies. Consider using first-person pronouns and active verbs (e.g. we found…) to clearly demarcate new results (Lanham 2000).
3. For brevity, consider introducing and using an acronym for the Northern Abalone Index Site Surveys (e.g. NAISS) throughout the main text.

SECTION 1: INTRODUCTION

The authors identify the Northern Abalone Index Site Surveys as a primary source of abalone information, and make reference to the existence of additional DFO studies that may supplement this information. They describe surveys occurring in a roughly five- years rotation, and remark on the overlap between some survey regions and the Species at Risk Act Recovery Strategy Biogeographic zones for Northern Abalone. I think the presentation of this material would be improved by tabulating:

a. Northern Abalone Index Site Survey regions, years each region was sampled, and corresponding Species at Risk Act Recovery Strategy Biogeographic zones (see example Table 1); and
b. Additional abalone study locations, years, and references (see example Table 2).

Table 1. Hypothetical table detailing Northern Abalone Index Site Survey regions, survey years, and corresponding Species at Risk Act Recovery Strategy Biogeographic zones.

Survey Region	Years	SARA Region
Name and acronym of Northern Abalone Index Site Surveys region	*List of years surveyed*	*Corresponding Species at Risk Act Recovery Strategy Biogeographic zone*
…	…	…

Table 2. Hypothetical table detailing DFO abalone data collected outside the scope of the Northern Abalone Index Site Survey

Location	Years	Region	Focus	Publication
Name of study location where data were collected	*List of years data were collected*	*Northern Abalone Index Site Survey region acronym (if applicable)*	*Research question or type of data collected*	*Citation including author name and year*
…	…	…	…	…

SECTION 2: BIOLOGY

1. The authors appropriately provide citations for summaries of Northern Abalone life-history in British Columbia. However, it would be helpful to provide an overview of abalone life-history including life stages and durations, and encompassing reproductive behaviour (e.g. mating season, spawning aggregations, broadcast spawning, etc.). This could form one new subsection.
2. The authors describe some important aspects of Northern Abalone habitat, including depth, substrate, and algal cover. However, this information is spread over several parts of the working paper. It would be helpful to provide a description of the Northern Abalone niche all

in one place (e.g. best information on depth, temperature and salinity thresholds; substrate, algal cover, exposure, etc.). This could form one new subsection.

3. The authors list existing abalone growth parameter estimates from several locations in BC across two studies (Breen 1986, Zhang et al. 2009), and provide new growth parameter estimates from previously unpublished data from a mark recapture study in Barkley Sound, BC, collected during 1991–1993. The authors compare their new estimates to those of Breen (1986) by ANOVA, and to those of Zhang et al. (2009) graphically.

    a. I am concerned that the authors appear to accept their null hypothesis (H_0: no significant difference in parameter values) based on high p-values ($p = 0.97$; $p = 0.44$), rather than failing to reject their null hypothesis. My understanding is that to accept a null hypothesis, a suitably high statistical power is needed (Peterman 1990, Stephens et al. 2007). I recommend the authors consider reporting the appropriate statistical power, or better, consider the alternative framework described below or similar.

    b. I am concerned that the phrase, “parameter estimates and 95% confidence intervals… overlap between the different sources (Figure 2)” may be misinterpreted to mean that the parameter estimates from all locations concur. Different from this, the confidence intervals around the growth curves for Lyell Island and Newberry Cove appear not to overlap between ages 3–20 years.

    c. I think a more informative approach to estimate abalone growth parameters in British Columbia may be to use all available data and fit one multilevel model (Gelman et al. 2012, McElreath 2015) that accounts for variation among study locations. This would produce global parameter estimates based on all available data and estimates of variation among locations, rather than multiple comparisons among different local estimates (Gelman et al. 2012). See Bolker (2009), Gelman et al. (Gelman et al. 2012) and McElreath (2015) for description and benefits of multilevel models (also known as mixed-effects or hierarchical models). The Bayesian model described in Zhang et al. (2009) or similar may be a useful starting place to develop a multilevel model for abalone growth.

4. The authors report size-at-age and generation time estimates in the Growth and Age subsection (2.1), but only maturity at size (not age) in the Maturity subsection (2.3). I think it would be helpful to report these estimates all in the same place, describe the methods used to estimate generation time, and discuss the strengths / weaknesses of converting maturity at size to maturity at age based on current size-at-age estimates. This could take place in the Maturity subsection.

5. The authors compare multiple length-weight relationship estimates from two previous studies and one new analysis. I think it would be helpful to use all available data and fit one multilevel model (Gelman et al. 2012, McElreath 2015) that accounts for variation among study locations. This would produce global parameter and estimates of variation among locations.

6. The authors report the results of a number of studies on abalone growth, weight-at-age, fecundity, etc. It would be helpful to report the sample size for these studies, in addition to the parameter estimates (e.g. number of individuals or quadrats depending on the context). These could be included in the main text, or as numbers paired with plotted means in the appropriate figures.

7. The authors report alpha and beta parameter estimates (subsection 2.5, page 9) for a cryptic probability model described in Appendix A. It would be helpful to provide the biological interpretation of the parameters along with their estimates in the main text.

8. The authors observe that their cryptic probability model for the Central Coast, “did not fit the data well, likely because the observations came from index sites both with and without sea otters present” (subsection 2.5, page 9). It would be helpful to focus on the results of the subsequent Central Coast model fits (and their quality) that account for sea otter presence / absence, rather than leading with the initial model.
9. The authors report new abalone annual mortality estimates based on the “stock- recruitment models of Zhang et al. (2007)”, and observe that the estimated mortality rate for East Coast Haida Gwaii was higher during 2012–2017 than 1990–2012. They suggest that the elevated estimate of mortality during 2012–2017 may be due to increases in the density of juvenile but not adult abalone abundance.
    a. It would be helpful to summarize the methodology that they use in an appendix.
    b. I think further details would help clarify their explanation for an elevated mortality estimate. For example, have juvenile densities been growing for >5 years? If not, the bump in juveniles may not have had time to recruit to the adult population, meaning that stable adult density need not imply increased mortality. I am concerned that the current explanation, “high mortality rate… due to the lack of increase in adult” density appears to reverse cause and effect. It seems more reasonable to me that a high mortality rate would prevent an increase in adult density, rather than stemming from the absence of an increase in adult density.
    c. It would be helpful to describe the reason for choosing 2012 as the cut off between the mortality regimes in ECHG. Was this chosen for some biological reason, or after inspection of the model fit? Why are the 2012 data included in both periods (1990–2012 and 2012–2017)? Are the differences in mortality estimates less pronounced with other cut off years? It would be helpful to provide justification for these decisions.
    d. Some average annual mortality rate estimates are extremely high. For example, 0.59 over five years in ECHG. It is unclear to me how a population could persist under these conditions. Some discussion of why the estimates are so high and whether they are plausible would be useful.
10. The authors refer to annual mortality rates and instantaneous mortality rates. It would be helpful to specify average / instantaneous and annual / other time period for each type of mortality rate for clarity. For example, “average annual mortality rate” and “instantaneous annual mortality rate”. It would also be helpful choose one type and convert the others for ease of comparison.
11. The authors define recruitment as “the rate at which Northern Abalone become part of the adult size category (≥ 70 mm)”. However, they go on to report recruitment estimates from Zhang et al. (2007) as densities of (age-4 cryptic and exposed) abalone per m^2. I think the discussion of recruitment would be improved by clarifying the definition of recruitment (abundance per m^2? Some measure per year?), correspondence of the definition to that in Zhang et al. (2007), and basis in size (e.g. ≥ 70 mm as described) or age.
12. The authors state that the stock-recruitment curves of Zhang et al. (2007) were “relatively flat and linear, indicating a lack of compensation or depensation at low spawning densities < 0.05 kg/m^2” (subsection 2.5, page 12). They conclude the subsection by stating, “McShane (1995) reviewed the literature on stock-recruitment relationships for abalone species and reported that spawner abundance contributed little to the variation in recruitment” (subsection 2.5, page 13).

a. I am concerned that the adjective “flat” may be misinterpreted as “recruitment did not increase with increasing spawning biomass.” By my reading of Zhang et al. (2007), the stock-recruitment curves were not flat, but rather were sloped indicating increasing recruitment with increasing spawning biomass, especially at low spawning biomass.

b. I am concerned that the phrase “relatively… linear” may be difficult to interpret. For example, relatively linear by comparison to what?

c. I am confused by the reference to McShane (1995) – it is more than a decade older than Zhang et al. (2007) and by my reading, focusses on the whole genus rather than Northern Abalone alone. Is the assertion that “spawner abundance contributed little to the variation in recruitment [across the genus]” useful here, when the more recent study by Zhang et al. (2007) found, by my reading, a clear positive relationship between spawning biomass and recruitment in Northern Abalone?

13. Are sex-ratios thought to constrain abalone fecundity? It could help to address this briefly.

SECTION 3: GENETIC DESCRIPTION AND DESIGNATABLE UNITS

1. Are there non-genetic markers relevant to designatable units, for example, abalone morphology, behaviour, or natural breaks in distribution?

SECTION 4: DISTRIBUTION

1. Figure 10 (Possible distribution of Northern Abalone in Canada) appears show information already presented in Figure 9. Could Figure 10 be used to show the estimated extent of occurrence instead?

SECTION 5: POPULATION TRENDS

1. The authors assemble standardized abundance indices for Northern and Southern BC abalone, using a Bayesian hurdle model and environmental covariates identified from a General Additive Model. It would be helpful to revisit the convergence diagnostic for the hurdle model (Appendix D) described below.
2. The authors suggest that estimated increases in recent juvenile abalone densities in Northern BC are due in part to declines in the sunflower star since 2013. The authors cite Schultz et al. (2016) who link the sunflower star to predation on gastropods generally. It would be useful to cite a study that shows sunflower star predation on Northern Abalone specifically.
3. There appears to be an error at the end of the second paragraph, page 19: “… the variation among the three… regions… was generally less than the difference with the previous period the three regions were surveyed.” It sounds as though the variation may have decreased, although it’s unclear to me compared to what.
4. The authors state that the estimates from the hurdle model cannot be compared to the “mean densities of the Population and Distribution Objectives” (page 19). Why is this?
5. The authors compare the most recent estimates to the 1978 estimates (page 22). However, they report the recent estimate as a percentage of the 1978 estimate in some cases and as a percent difference from the 1978 estimates in other cases. It would help to make the same temporal comparison the same way for all regions. Repeated for Southern BC (page 23).
6. The authors state, “Based on the 95% credible intervals, there is at least a 95% probability that the 2016 estimated mean adult density for CC is lower than the 1978 estimated mean adult density” (page 22). I would argue that there is a 100 % probability that the 2016 adult mean estimate is lower than the 1978 adult mean estimate, because the mean estimates

are known and the 2016 estimate is lower. I think this sentence could be rephrased to address the probability that the *true* mean adult densities differ in the direction indicated, conditional on the assumptions inherent in the model. Similarly for ECHG and west coast Haida Gwaii (WCHG) (with appropriate changes).

7. The authors state, "the 95% credible intervals overlapped for all these estimates, meaning the probability that the true densities were different was less than 95%" (page 24). I think this interpretation may be misleading. I would argue that because the densities are point estimates that occur on a (nearly) continuous scale, the probability that the densities are different is (nearly) 100%. Instead, I think it would be helpful to report a different interpretation of the meaning of overlapping credible intervals. I think it may be useful to quantify the probability that the population density has declined by X percent, corresponding to some biological reference threshold.

SECTION 6: POPULATION SIZE

1. The authors describe an effective population size for Northern Abalone of 370,000 (page 26). I'm curious how quickly effective population size tracks the abundance of reproducing adults. For example, if 50% of reproducing adults perished now, how many generations would it take for the allele frequencies in the population to reflect this change? If the lag is long (decades?) this may be useful context to understand how the effective population size relates / does not relate to the current abundance.

SECTION 7: HABITAT

1. Based on the Terms of Reference (5) it may be helpful to state whether Northern Abalone has a "residence" (defined in the TOR).

SECTION 8: THREATS

1. Figure 18: It would be useful to show sea otter range, abalone range, and the range overlap as three contrasting colours / shades to clarify the distribution of both species on the same map.

APPENDIX A: ESTIMATING MORTALITY RATES

1. Equation A.3: It would be helpful to provide a table identifying each symbol (including subscripts) by a name and description, for example following Edwards and Auger-Methe (2019). I'm also confused by the model structure. Variables *D* and *D-tilda* appear to be the observed density and the predicted density in each survey area (*l*) and year (*y*), respectively. Am I right in thinking that *D-tilda* is the predicted *D* at year *y* + 1? If so, I think this would be shown more clearly by using *y* + 1 in the subscript. Next it looks like the average annual mortality rate is raised to the 4^{th} or 5^{th} power given by N_y depending on the number of years between surveys at a given location. Okay. But why is *R4* always switched on, while *R5* is sometimes on and sometimes off depending on the value of f_y? Shouldn't *R4* be on when *R5* is off and vice versa? Shouldn't *R4* be scaled by natural mortality similar to *R5*? This is confusing to me, and a table identifying each symbol (in particular, *R4* and *R5* separately) would help. Finally, epsilon is present in the equation, but I don't see where it is defined. I imagine it's a random variable from a non- negative error distribution? Which one? My guess is that subscripts *y* and *l* could clarify its interpretation. Finally, it would help to name the framework used to fit the model.

APPENDIX C: ESTIMATION OF EXTENT OF OCCURRENCE USING HABITAT SUITABILITY INDEX MODELS

1. A map would help to illustrate the HSI extent of occurrence. Would it be possible to include one?

APPENDIX D: ESTIMATING A STANDARDIZED INDEX OF ABUNDANCE FOR DFO NORTHERN ABALONE INDEX SITES SURVEYS

1. The authors report using as a convergence diagnostic the “ratio of the pooled posterior variance to the average within-sample variance” (page 52). I think this is the traditional potential scale reduction factor, R-hat (Brooks and Gelman 1998). The traditional R-hat has several shortcomings, and has been improved on in the split-R-hat and then subsequently the improved-R-hat based on rank-normalization, folding and localization (Vehtari et al. 2019). It would be helpful to report the convergence diagnostic method (ideally the improved-R-hat) and convergence statistics in the manner described by Vehtari et al. (2019).

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