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Proceedings of the regional peer review recovery potential assessment offshore killer whale

May 27-28, 2013
Nanaimo, British Columbia

Chairperson: Linda Nichol
Editor: Linda Nichol

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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 May 27th and 28th, 2013, at the Pacific Biological Station in Nanaimo, British Columbia. One working paper was presented for peer review.

In-person and web-based participation included DFO Science, Fisheries Management Sectors staff; and external participants, Department of National Defense, Province of British Columbia, consultant researchers, and academia.

The conclusions and advice resulting from this review will be provided in a Science Advisory Report to the DFO Species at Risk Program, to provide an assessment of the most current information about Offshore Killer Whales and the population's potential for recovery.

The Science Advisory Report and supporting Research Document will be made publicly available on the CSAS Science Advisory Schedule

Compte rendu de l'examen régional de l’évaluation du potentiel de rétablissement de l'épaulard océanique

SOMMAIRE

Le présent compte rendu résume l'essentiel des discussions et conclusions de la réunion régionale consultative du Secrétariat canadien de consultation scientifique (SCCS) de Pêches et Océans Canada qui a eu lieu les 27 et 28 mai 2013 à la station biologique du Pacifique de Nanaimo, en Colombie-Britannique. Un document de travail a été soumis aux fins d'examen par les pairs à cette occasion.

Au nombre des participants qui ont assisté à la réunion en personne ou par conférence Web, il y avait des représentants de la Direction des sciences et de la Direction de la gestion des pêches du Ministère, des participants de l'extérieur du ministère de la Défense nationale, de la province de la Colombie-Britannique, ainsi que des experts-conseils en recherche et des intervenants du milieu universitaire.

Les conclusions et les avis découlant de cet examen seront transmis dans le cadre d'un avis scientifique au programme des espèces en péril de Pêches et Océans Canada afin de fournir une évaluation des données les plus récentes sur les épaulards hauturiers et le potentiel de rétablissement de leur population.

L'avis scientifique et le document de recherche à l'appui seront rendus publics dans le calendrier des avis scientifiques du SCCS.

INTRODUCTION

A Canadian Science Advisory Secretariat (CSAS) Regional Peer Review (RPR) was held May 27th and 28th, 2013, at the Pacific Biological Station, Nanaimo, British Columbia, to review one working paper that was written to provide an up to date assessment of Offshore Killer Whale population status and potential threats to recovery and probability of recovery of the population. The purpose of the CSAS review was to assess the completeness of the information as this will form the scientific basis for the development of the recovery strategy.

The chair, Linda Nichol, welcomed participants and 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, confidentiality requirements and the expected RPR document outputs (Science Advisory Report, Proceedings and Research Document) and their general purposes, as defined by CSAS. Everyone was invited to participate fully in the discussion and contribute knowledge to the process, with the goal of delivering a scientifically defensible product. It was confirmed with participants that all had received copies of the RPR Terms of Reference (Appendix 3) and the working paper. The Chair reviewed the agenda with the participants. Robin Abernethy (DFO Science) was identified to the meeting participants as the rapporteur for the meeting. Jonathan Thar (DFO SARA-FM) also provided a brief overview of the DFO SARA role in developing a recovery strategy and action plan for Offshore Killer Whales, and thus the purpose and reason for the Offshore Killer Whale recovery potential advice.

The meeting participants were informed that Dr. Jack Lawson, Marine Mammal Section, DFO Maritimes Region, St. Johns Newfoundland and Dr. Lance Barrett-Lennard, Vancouver Aquarium, Vancouver, British Columbia had been asked prior to the meeting to provide detailed written reviews of the working paper. These reviews are intended to assist in shaping the review, but not to limit in anyway, discussion by participants attending the peer-review meeting. The working paper authors were provided with copies of the reviews in advance of the meeting so that they were prepared to respond to the issues raised by the reviewers. Meeting participants were also provided with copies of the written reviews.

The Chair referred to the Terms of Reference (TOR) for the meeting (Appendix 3), and highlighted the objectives of this meeting. In total, 19 people participated in the RPR (Appendix 2).

DETAILED COMMENTS FROM THE REVIEWERS

Working Paper: Ford, J.K.B., Stredulinsky, E. H., Ellis, G. M., Durban, J.W., Pilkington, J.F. 2013. Offshore Killer Whales in Canadian Pacific Waters: Distribution, Seasonality, Foraging Ecology, Population Status and Potential for Recovery. DFO Can. Sci. Advis. Sec. Res. Doc.

Working paper accepted with revisions

REVIEWER # 1 JACK LAWSON

General Comments

The reviewer noted that the purpose of the working paper was stated clearly, and the writing and presentation concise and thorough. The broad subject and temporal range of supporting data, and methods used to gather and analyse it, were adequate to support the conclusions of the authors.

The presentation of the information that has been gathered on this population was presented in ways that clearly depicted the uncertainty in the data, analysis, and collection processes.

Specific Comments on Terms- of-Reference Objectives

Although the reviewer found that the data and methods were explained in sufficient detail to properly evaluate the conclusions, he thought more research on movements and distribution would be useful given the statement "*Potential critical habitat for OKWs in Canadian waters cannot yet be identified given the current lack of information on seasonal distribution in outer coast waters and the prey resources that may determine habitat quality.*" Further efforts to track whales using satellite tags and/or further photographic-based studies should be considered.

The author commented that the study is ongoing, and that it is contingent on resources. A discussion of some of the specific issues with satellite tagging followed. Although satellite tagging has good potential for unbiased data on movements, it does require significant effort and luck to successfully attach a tag and receive transmissions. Further there is a need for an adequate sample size of tagged animals. From a technological perspective there are still issues with the attachment and with the transmitting duration of tags that need improvement. Finally there are concern regarding tag attachment wounds and as a result there has been hesitancy to use the tags on animals until the consequences of attachment wounds have been better researched. Given these risks, there is also a desire to maximize data acquisition and so tags that could provide additional information besides location such as time and depth data are desirable. There was some discussion and information presented about pathology and inflammatory response and infection associated with tagging. The Chair suggested the reviewer's comment was really about ensuring that the authors articulate the need for further research to track whales and understand their distribution and habitat, rather than the specifics of satellite tracking. It was agreed that recommendations for further study would be included in the advice document.

The reviewer suggested that the conclusion that the preferred prey species for these whales are monitored adequately by the Department could be tempered by a statement of caution that such monitoring should be assigned a high priority if further funding reductions or reallocations be incurred by the Department.

The author explained that Jackie King (Pacific Biological Station,Nanaimo, BC, pers. comm.) indicated that ground fish CPUE is monitored but the data are not analyzed, but improvements

in monitoring could in theory be made. He also pointed out that this has been done in southeast Alaska with Sleeper Sharks and the analysis has demonstrated an increasing trend. The author agreed that monitoring and analysis of prey using CPUE fishery data should be done and that this should be included in the Science Advisory Report as a recommendation.

The reviewer was surprised at the lower proportion of OKW offshore “encounters” that were based on acoustic records relative to visual information. The reviewer wondered if this was a function of a paucity of acoustic detectors deployed in offshore areas, then the authors should recommend that additional acoustic receiver deployments be considered to provide information on OKWs’ seasonal distribution in outer coast waters.

The author agreed that they would include a recommendation to deploy additional acoustic receivers with a priority to put acoustic receivers closer to the slope. The author also acknowledged that there are acoustic data that have been collected but not yet analyzed and that this should also be a priority.

Another author, involved in the analysis of acoustic recordings specifically for Offshore Killer Whale calls pointed out that only a few recordings have been analysed. So far, the acoustics have resulted in many acoustic detections. The author commented that analysis of the unprocessed acoustic data by experienced acoustic personnel is a priority. The author noted that acoustic analysis of recordings of Offshore Killer Whales thus far has indicated a pattern of calls that reflects dynamic connections within the social network.

Some additional discussion ensued with various questions about vocal activity and detection. The author clarified there is no obvious seasonality to the vocal activity, unlike humpback whales, thus there is equal probability of detection at any time of the year. It was pointed out that some acoustic recorders are monitoring continuously while some are on a duty cycle. Could there be a difference in detection of Offshore Killer Whales between these two monitoring types? The author pointed out that given the size of Offshore Killer Whale groups and the time it takes for these large groups (usually spread out) to pass an area there is good probability of them being detected even with a duty cycle. Another observation presented was, that Offshore Killer Whales use a high intensity echolocation compared to the two other ecotypes of killer whales in BC. The different echolocation sounds may provide some insight into the type of foraging habitat in which these animals operate. Another acoustic specialist participant pointed out that the different acoustic environment on the shelf may explain the need for a different echolocation signal.

Reviewer 1 asked if the apparent increase in the number of nearshore encounters with OKWs could they be a result of expanding range, or returning to historic habitat? The author clarified that each interpretation would lead to a different conclusion and therefore caution should be used when interpreting as there is no way of evaluating either as good or bad. A participant wondered if this shift or expansion might be related to Pacific Decadal Oscillation (PDO) either directly or through its influence on prey. The author had not looked at PDO but noted it would not be hard to do so, although it may not resolve anything.

Reviewer 1 felt that the document did not present much advice to decision-makers since it appears that the population of killer whales has a stable (albeit low) abundance, and their habitat does not face mitigable threats.

REVIEWER # 2: LANCE BARRETT-LENNARD

General Comments:

Reviewer 2 commented that the working paper was well-organized, well-written and represented a thorough and careful synopsis of the present state of knowledge regarding the Offshore Killer Whale (OKW) population. The purpose and scope of the paper were clearly laid out and uncertainties in the seasonal distribution and foraging ecology of the population and the effect of those uncertainties on the conclusions were acknowledged and discussed. The OKW population was identified relatively recently and because of its distribution and range is inherently difficult to study. As a result, there is relatively little published literature on the population and the authors' task was challenging. As such they assembled and analyzed occurrence and dietary data in a manner more typical of a publication in the peer-reviewed literature than a document intended to inform management decisions. The diligence they put into their effort has made for an interesting review.

Specific Comments on Terms- of-Reference Objectives

Reviewer 2 focused their comments in three areas: distribution, abundance and population trends, and recovery potential. They had no significant comments on the other parts of the paper other than to say that they were well-researched and well-presented. The reviewer concluded that the paper was an accurate and complete summary of information bearing on the recovery potential of OKW and that only minor changes, particularly to parts 13 and 15 of the final section, were needed to finalize it.

Distribution

The following sentence appeared on p 6: "It is thus apparent that a shift in distribution took place in 1992, with OKWs expanding their range to include periodic visits to inside waters, at least around Vancouver Island." The case that a change in the visitation rate to inshore waters occurred around 1992 is convincing, but it was suggested the authors should note that it is unknown whether the visits were new or a return to areas used prior to the commencement of surveys in 1973. Also, because it is unknown whether the move occurred concurrently with a shift away from other habitats, it should not be characterized as a range expansion. The importance of getting these nuances right is that they influence how we think about the role of habitat in limiting OKW numbers and its impact on recovery potential. The author acknowledged this point and that it was raised by Jack Lawson as well and noted that we cannot say it is a shift and we cannot say it is an expansion. The research document and the Science Advisory Report (SAR) will be edited accordingly.

The discussion around this point included recognition that we do not know how or if they continue to use other habitat. We can only say that they were not here in inshore waters before, but we do not know what is going on outside of the areas where we see them. It could also be a return to traditionally occupied areas, a change within the time series that we have to work with. Another point was made that we made need to consider the possibility of unexplored dynamics between the different killer whale populations and this, rather than prey or PDO could be affecting distribution patterns. Finally a point was made that linked this discussion to recovery distribution goals stated in the research document that have been drawn from the management plan. Given that we do not know if or what caused a distribution shift, nor whether it is good or bad, what if another shift occurs?

Reviewer 2 drew attention to a further section of the paper and pointed out that the authors wrote "….it is apparent that the OKW's primary habitat is outer continental shelf waters". The

reviewer was uneasy about this conclusion. First, since the authors noted elsewhere in the text and in the figures, that OKWs have been seen and acoustically detected inshore many times, and sometimes stayed in those inshore areas for prolonged periods, high effort inshore notwithstanding. Second, because of the observation that the mean distance of OKW sighting locations from the 200-m isobaths is 38 km is partly a function of the existence of canyons and deep fjords that extend well into the continental shelf. Third, 'primary habitat' is undefined and as such does not lend itself to being "apparent". It might be better to just say that OKW spend less of their time in inshore waters that do resident and inner coast Bigg's killer whales and avoid referring to primary habitat. The reviewer also wondered whether the authors have looked at bottom slope as a predictor of OKW distribution as it might prove a more useful metric than distance to a given isobar. The reviewer noted that later in the paper, the authors refer to a possible latitudinal shift in the distribution of OKW and provide a figure showing the distribution of encounters by latitude. Given that the distribution of OKW sightings roughly parallels the coast, the seasonal movement picture might be clearer if the authors tilted their coordinate system anti-clockwise about 45 degrees and assessed the distribution in a NW-SE rather than a N-S frame of reference.

One participant provided a cautionary note that there is no definition of primary or secondary habitat in the document, but that it is critical habitat that will ultimately have to be identified. So it would be good to include definitions of primary and secondary in the document to avoid confusion. The author clarified what is meant by primary and that it is not critical habitat. A further description to clarify will be added to the research document. The authors explained that evidence suggests Offshore Killer Whales are off the slope more than in inshore waters and that was point they wished to make not necessarily that it was critical habitat. The authors pointed out that they did plot out trends with the 500 metre isobaths and the trend was stronger than with the 200 metre isobath. Another participant noted there was a spike in distribution at about 75 km from the slope and wondered if it was correlated to effort. The authors clarified that it was just noise in the data, the distance from the 500 meter was a stronger trend. Another participant suggested that a map of locations discussed in the paper might be helpful.

Abundance and Population Trends

Reviewer two found that the section on the use of a mark-recapture model to estimate population size and trends was written in a more compact style than the rest of the document and that it was harder to follow. A few wording suggestions were made and a request for additional clarification in the text. The reviewer had some concern as to how the authors assured that individuals that are non-distinctive in appearance (and accounted for separately from distinctive individuals used in a mark-recapture analysis), were not mis-assigned as new members of the distinctive category when they acquired scars or other marks as mis-assignments of the type described would result in artificially high estimates of recruitment rates. Methods description should be added to explain how this was dealt with. The authors agreed that this was a concern for them in development of this model. The concern is that if an animal is named in a year but then there is a gap in sighting history, and it is subsequently renamed unknowingly this would affect the model results. In the discussion that followed the authors explained that the method is specifically to reduce the possibility of mis-assigning animals and is thus very conservative. They explained that even the unnamed animals are tracked as carefully as the named animals (calves of females, tracked, looked for, etc.) in the photo-identification process which is the input data to the model. The presence of unnamed animals led to a question as to whether offshores are readily distinguishable from residents and that perhaps this should be made clear in the methods, or might this be a source of error in the model as well? The authors re-iterated that the social analysis presented in the research document shows that the offshore animals are linked together and there is no connection with other animals in other

populations. There were some US encounters that were excluded from the analysis if they did not meet the criteria for this analysis, even though they were published as offshore encounters. The criteria for including animals in the analysis were conservative – they had to have been seen with other known offshore animals. If animals were not seen with other known offshore animals they were not included in the analysis. Consequently there are a small number of encounters that were excluded from the analysis. The authors agreed to add more explanation and detail to the photo-identification method and criteria for including animals in the mark-recapture analysis.

Recovery Potential Analysis

Reviewer two noted the following. Section 13 of the Recovery Potential Analysis section of the paper makes the following statement: "*There is no evidence that the OKW population is habitat- or prey-limited, either over its total range or within Canadian waters. With a population of only some 300 animals and a range that encompasses the continental shelf waters for more than 5000 km of coastline, habitat limitation seems highly unlikely."* The reviewer argued that OKW likely are prey-limited, as evidenced by their apparently stable population size. As noted, they have no predators; acute disease and contaminant exposures are likely to produce fluctuating rather than stable dynamics. Therefore the reviewer suggest that the most parsimonious explanation for their observed dynamics is bottom-up forcing—i.e., prey limitation and further pointed out that they do have a huge range, and the fact that they roam vast areas in itself suggests that available prey are generally scarce. The locations where OKW can efficiently and productively hunt prey may be relatively few and far between. If this were so then the increases in at least two prey species that the authors refer to may represent a much smaller increase in prey resources available to the whales. It was suggested that the authors may of course have a good basis for not agreeing with this opinion here, but should in any case provide more explanatory detail. In addition, they should note, perhaps in section 16, that increased exploitation of elasmobranchs has the potential, at least, to negatively impact OKW.

It was pointed out that if the population is stable, then there is a need to try to explain why that is. Prey-limitation would be one reason. The authors acknowledged this was a good point. All the other populations are increasing, why not offshores? A discussion ensued and it was suggested that 300 animals should not be able to make a dent in the biomass of sharks and other prey thought to be available. So then the question is, is there something about the natural history of these animals that could be limiting their population? The reviewer suggested that despite the apparent prey biomass, if there are relatively few areas that are good for foraging, perhaps immigration into those areas could be limiting them. Also if the Offshore Killer Whale population were well below carrying capacity, it would be hard to understand why they roam as far as they do. The idea, that there may be inter-population dynamics was raised. Another possibility suggested was preference for one particular prey species, that we are not aware of, that they seek that may be limited and may be driving their movements. Perhaps shark livers are just snack food. However the authors explained they have looked at the energetic needs of offshores crudely and Sleeper Sharks would make up 99% of their energetic needs, but maybe the patchy nature of prey distribution may be a factor, also we do not understand the dynamics of foraging and group size in this population.

The reviewer clarified that he was not seeking an answer to this but rather that there should be acknowledgement made in the document that there could be some evidence of prey limitation, he did not like the wording that there is no evidence of prey limitation. Also he stressed that it was worth changing the wording because it is possible that increased shark exploitation could negatively affect the abundance of the offshores killer whales. The authors agreed to expand the section to include more discussion of other factors that may be limiting access to prey, as well as uncertainties regarding prey. Also that analysis of monitoring catch data needs to be a

priority. Another participant referred to a paper (King and McFarlane 2009) in which there has been effort to reconstruct dogfish catch data prior to 1996. That analysis shows that dogfish numbers decreased (were higher prior to 1996). Prior to 1996 huge amounts of dogfish were taken before fisheries observers were placed on vessels. Perhaps the range change of Offshore Killer Whales reflects rediscovery of areas that were important. Recovery of dogfish populations from depletion could be very slow due to life history of the dogfish. Another participant noted that prey may be abundant but not accessible to Offshore Killer Whales. Shark research on shark behavior indicates they may have predator avoidance behaviors.

A question was raised by a participant as to whether there are any data on contaminant loads in Offshore Killer Whales as they may be high if they are eating the livers. The authors indicated that Offshore Killer Whales show a different type of PCBs. PCBs levels are high, but not sure how this translates into potential population effects also little can be made of these data from biopsied animals because age / sex information is lacking from the biopsied animals.

The Chair summed up the changes that the authors should make to the research document and the SAR. Authors would be less definitive about prey limitation, and they would address uncertainties of foraging behaviors and access to prey.

Section 15 of the RPA part of the paper consists of the following statement :"Potential critical habitat for OKWs in Canadian waters cannot yet be identified given the current lack of information on seasonal distribution in outer coast waters and the prey resources that may determine habitat quality". Reviewer two noted that this short categorical statement was a departure from the carefully-considered tone of the rest of the paper. Arguably, OKW critical habitat could be justified in two apparent hotspots, near Langara Island and SE of Moresby Island, based on similar logic to that used in the Resident Killer Whale Recovery Strategy. These areas, which stand out in the figures and are discussed in the paper make up only a small percentage of the range of OKW of course, but the Species at Risk Act is precautionary with respect to critical habitat, specifying that recovery strategies "…must include an identification of the species' critical habitat, to the extent possible, based on the best available information…" (SARA Section 41). If the authors feel that they could not justify identifying these areas as potential critical habitat they should provide at least a brief explanation.

The reviewer questioned the decision expressed in the research document to not provide advice on critical habitat to the extent possible. He wanted to open discussion due to wording in the working paper that describes some general areas such as Langara Island, southeast Moresby Island and southwest Vancouver Island where encounters are common. The reviewer felt that these areas arguably, if we had to make our best guess, would be critical habitat, while there might be less confidence in the satellite tagging and the Learmonth Bank encounter because they were single events each.

In response to this the authors expressed the opinion that the reviewer was overstating his generalizations and pointed out there has been huge effort at Langara and southeast Moresby Island but much less off southwest Vancouver Island. If it is based on prey concentrations then perhaps those areas would be important. The reviewer still felt that a recommendation of critical habitat based generally on slope habitat would not be outrageous to include, similar to what has been done with leatherback turtles. He pointed out that three lines of evidence leads to supporting a critical habitat description – these are; distribution of sharks, observations of the killer whales, observations of the killer whale predation events in the slope locations.

It was suggested that synoptic ground fish research survey data may have better data for dogfish distribution and other sharks than the CPUE data from the commercial catches. The author pointed out that killer whales generally go for high lipid content and as such dogfish would likely make up only a small amount of prey. He thought it more likely Offshore Killer

Whale are driven by distribution of the large Sleeper Sharks and possibly other species such as Salmon Sharks. So even if we were to suggest potential critical habitat based on prey it would be necessary to focus on the larger shark species, not dogfish.

A question was raised, what would be necessary to leave the door open to identifying critical habitat? The Chair suggested it might be helpful to identify what we do know what we do not know, rather than focusing on what is strong enough information and what is not. It was pointed out that we can leave it to the recovery team to then make the decision about critical habitat and this meeting could focus instead on listing data discrepancies.

The author reminded us that the data are so seriously biased for effort that it is risky to identify critical habitat at this time. Another participant pointed out that the shark CPUE data are also biased, they are all driven by quotas (and market value?) so the prey data set may be just as risky. The author commented then that only further supports the concerns we have about data and that we should not be recommending critical habitat at this time. Again it was suggested that the task should be, given uncertainty in the data sets, just describe in the research document and in the SAR the data sets that could be used to identify critical habitat.

The Chair concluded this discussion with a sum up. The authors and participants should consider the evidence they have, quantify the issues, and set out what you could do in the future. Focus on the evidence we do have to help direct future discussions.

GENERAL DISCUSSION

The Chair opened the floor for comments and discussion by all RPR participants. The following represents the nature of the discussion organized by general topics

TOOTH WEAR AND IMPLICATIONS

With regard to the existing hypothesis that extensive tooth wear observed in Offshore Killer Whales is a result of frequent contact with abrasive shark skin, a participant asked if anyone has tried to achieve such wear on sample killer whale teeth by rubbing them with shark skin in a lab or controlled setting. The author described tooth wear analysis that has been undertaken which involved analysis of denticle spacing in the teeth. However this method was abandoned as it was too difficult. It was suggested that electron microscopy might be important to that investigation.

A discussion of other sources of human induced mortality followed. It was pointed out that a large die off of marine mammals in Alaska has occurred. There was information provided about the effects of radioactivity resulting from the Japanese Tsunami and nuclear power facility accident in 2011 on ring seals in the Arctic. Liver or skeletal muscles can be used to look for similar effects in killer whales. At this time it is not possible to use skin biopsies samples for this but a protocol is being developed.

Other pathological issues for marine mammals can arise from land based pathogens that spill over into marine mammals. Although parasites may be carried by a whale and not cause illness, under stress in the whale, these same parasites could become a fatal issue. It was suggested that some of this material regarding pathogens and vectors be included in the document**.** There was further discussion about tooth wear and its possible implications for Offshore Killer Whales. A comment was made regarding the rapid pace at which the teeth are worn down indicated by extensive wear in young animals. It was suggested that they must be sharing prey to help animals with worn teeth. Tooth wear has implications for social structure. Food sharing may be even more important than in the other ecotypes of killer whales. It was suggested that there may even be a reversal of what is seen in resident killer whales, perhaps among Offshore Killer

Whales it is the younger animals that are sharing with older animals. Could this have an effect on group size? Another participant asked if teeth were collected for analysis from the mass stranding event near Masset in 1941 or the mass stranding event at Estevan Point in 1945. The authors clarified that other than photographs and measurements of animals, only one skull was collected.

The author acknowledged that there is work to be done. In particular to look at structure and details of tooth wear and to ascertain if there are anthropogenic effects to the tooth wear. With regard to prey capture, the author clarified that killing is by ramming. Teeth are for pulling prey apart, as such, the author was not sure that having flat teeth is that debilitating to foraging behavior. However, if a fresh Offshore Killer Whale specimen should be found, it would be important to look at the gums and the skin around the mouth.

A question was asked whether there are issues with the chemicals in the shark tissue that may also be a contributing factor to tooth wear. The authors acknowledged these possibilities, but whatever the cause they noted that tooth wear seems not to be affecting life history and that survival seems to be similar to resident and transient ecotype killer whales.

POPULATION SIZE AND DISTRIBUTION WITH RESPECT TO RECOVERY OBJECTIVES

A question was asked as to whether the authors considered amending the recovery objectives that they included in the research document that were taken directly from the Offshore Killer Whale Management Plan. The authors replied that they did not because they had no new information with which to inform a revision of the objectives at this time. However they acknowledged that it would be good to advise that the objectives be revisited. They pointed out however that it is important to recognize that killer whales have a predisposition to exist in small populations. Therefore we can say we want a larger population size, but it may not occur. We can only expect a certain density of an apex predator. Therefore, the authors were hesitant to put a number on a population target referencing where we want the population be.

How could one support an increase in the population? It was suggested that the authors clarify this in the research document and in the SAR, if the group agreed. Also why were the authors hesitant to quantify population targets? This would address the issue clearly so that it would not be dug up again in the future through other processes, e.g. recovery strategy. The authors pointed out that they are using a modeling approach to estimate the population size of Offshore Killer Whales. As such they are concluding that the population is stable but it is a model and as such a crude estimate compared to the population estimates we have for Resident Killer Whales. It may take another 10 years to measure a number. Therefore it is difficult to set a quantifiable variable. Another participant pointed out that there may be other issues besides prey, such as social factors, that limits the population size so again, difficult to put a number on a population target.

There was a discussion about using the word recovery as it has a specific meaning in a recovery strategy. The Chair reminded everyone that the meeting is to obtain the science advice the specific wording of recovery objectives will be the work of the Offshore Killer Whale recovery team.

The Chair asked if the following observation needed clarification. The Offshore Killer Whale population is doing about the same as other killer whale populations and asked if this needed further discussion. The authors clarified that recruitment is low in the Offshore Killer Whale population, compared to residents and transients in BC and Alaska. Why the offshore population is not growing is unclear. We do not have enough information on their life history

parameters to know why this is, but we do have some confidence that the population is not declining.

A comment was made that there may be cultural factors that are affecting distribution and that these may change very slowly. There was another comment with regard the mark-recapture model. While it does a good job of getting a population estimate, it is likely that there is far less accuracy with the other parameters and that trends are very difficult to access and this should be reflected in the SAR. The authors acknowledged that we have poor information on sex/life parameters and that the resolution of the data we do have is courser than for other ecotypes**.** This is important and will be reflected in the SAR.

HABITAT

Clarification was provided that the task the RPA was not to identify critical habitat. The discussion and advice should be to identify sources of information that could be used to inform critical habitat and to provide discussion as to whether there is enough information.

There were 4 broad categories of information noted:

- Shark species
- Satellite tagging results and other distributional information from photo-identification encounters and acoustics
- Bathymetry and relation to shark distribution
- Tooth wear as an indicator of diet

A question was raised about acoustic data. How much is there and how long until the analysis is completed? Clarification was provided that Moresby Trough and Juan Perez Sound deployments have not yet been analyzed. Regarding analysis, the author explained that there is an auto-detection algorithm which is available which helps with analysis. Another participant added that detectors are being improved in addition to the development of classifiers (killer whale calls vs. boat noise), although they have limitations. The authors clarified also that acoustic recordings analyzed that result in no Offshore Killer Whale calls detected also provide important information potentially about absence.

There was agreement that a schedule of studies with respect to critical habitat will be presented in the recovery strategy. Also there should be ongoing survey effort off of southwest Vancouver Island. The author acknowledged that the working paper is light on detail regarding critical habitat. The list of studies that needs to be in the research document needs to draw together how various data could help to identify critical habitat. Following from this point the author suggested an important recommendation is to look at modeling and analysis of shark catch and synoptic fishery independent survey data.

A participant pointed out though that we need to clarify if we would be suggesting critical habitat be based on foraging function. Because if we are then we need to be very clear that although we are using all this shark data we actually have a very poor understanding of the species composition of their prey base and that the sample size of diet data is incredibly small.

It was suggested that the authors include in the research document a table of the potential prey items and life history characteristics of these prey items, as well as their habitat, migration patterns and caloric value. Following from this suggestion, another participant noted that Sleeper Sharks are found to travel up and down in the water column (based on time-depth-recorder (TDR) research). Perhaps TDR studies on Offshore Killer Whales would be useful. The authors pointed out that observations of foraging indicated that the whales at Learmonth Bank

were feeding at depth during the day. It was also suggested we might consider the spawning habitat of sharks; perhaps certain species become inaccessible at certain times.

There was a question about whether recovery strategies can be amended. This was with reference to what might happen in terms of critical habitat studies if our understanding of what is important to Offshore Killer Whales were to change. Clarification was provided that yes a recovery strategy can be amended but it is more efficient to capture changes in the action plan stage.

The discussion then turned to threats to habitat (critical habitat). The author indicated that acoustics is going to be an important characteristic of critical habitat for Offshore Killer Whales. Characteristics of Offshore Killer Whale sounds may provide inferences about the habitat and the prey they are seeking. It was pointed out that the higher intensity of echolocation reported for Offshore Killer Whales perhaps makes sense if they are working in deeper water. The author explained that Offshore Killer Whales make ultrasonic calls and thus the threat of acoustic masking may be higher for Offshore Killer Whales than for other ecotypes. With regard to the sound environment it was is noted that if Offshore Killer Whales are working in deeper waters offshore they may be getting away from the surface noise.

The author remarked that prey density and accessibility are key drivers to movements of Resident Killer Whales. All other activity states occur between foraging bouts. It seems likely that this is the case for Offshore Killer Whales as well. However a participant pointed out that some killer whales in the southern hemisphere travel 1,000s of kilometres into subtropical waters apparently to replenish skin cells.

A participant suggested that perhaps there is a need to be in a larger group for prey sharing. Thus anthropogenic activities that break up that group could affect accessibility to the habitat. This should be considered in relation to the critical habitat. The author, however, was of the opinion that since all the animals have worn down teeth by the time they reach maturity it is difficult to accept that they need the young animals with teeth to survive. But one participant wondered about gum tissue as well. Why are the gums not abraided heavily as well? It was noted that shark livers would be like eating Pablum for older animals. And it would seem as they wore down their teeth – switching to other prey would become less possible. However it is also noted that observations of killer whales in captivity indicate that fish prey are easily broken apart by a shake of the head and certainly killer whale teeth are not really for shearing anyway. Another participant noted that narwhal, which do not have teeth, eat Greenland Halibut. With regard to tooth wear it was noted there may be a difference between chronic slow exposure of tooth pulp cavities versus a sudden acute exposure. With constant chronic exposure animals may develop a bit of immunity versus acute exposures observed in some Resident Killer Whales.

With respect to Section 15 in the research document which is about identifying threats to habitat that may be critical, one participant suggested that the authors elaborate on the confidence of the advice they have given so that if recovery planners make decisions they know the confidence. The author indicated that that section will be fleshed out in the research document and the SAR to incorporate the elements from the meeting discussions.

The Chair provided a brief sum up. From the discussions about habitat, prey, prey limitation, much of the key points would be captured under sections 7, 8, 9, 11, and 13 of the research document and in the background information sections too. They will also be captured in the SAR.

It was noted that we need to identify gaps and what work needs to be one. This need not be an exhaustive list in the research document. The Chair asked participants if they felt they had

discussed critical habitat enough including the gaps and the general types of studies needed. It was pointed out that the proceedings of the meeting will capture all of the discussion and elements of suggested studies to identify critical habitat.

The second reviewer described a methodology recently developed to estimate effort to apply to nonsystematic sighting data collected by the British Columbia Cetacean Sightings Network (BCCSN). With this analysis he showed that areas of southwest Vancouver Island and Moresby Island may be important to Offshore Killer Whales. The author expressed concern, however, that there should be photo-id data from each of the encounters with Offshore Killer Whales taken by each of the user groups presented in the sightings effort model to confirm it was offshores they saw and not residents or transients. The author noted that from the map figure presented that offshores are not in the areas where there is effort. There was agreement however to include as a recommendation for further study an effort model for nonsystematic sighting data.

Prey Limitation and Body Size

It was noted that there was no discussion of body condition or body size in the research document, even though being smaller could be due to prey limitation. This could go in a schedule studies. The author however, pointed out that despite an impression that offshores are smaller it turns out not to be the case. Necropsy measurements show females are basically the same size as resident females and this is also the case with males too. Dorsal fin size on the other hand is smaller in offshores and this can be misleading. It is unlikely that skeletal length would show prey limitation, girth might but not length. The author concluded that any sign of nutritional stress should be looked for and monitored. Another participant recommended adding a list of studies identifying key indicators of nutritional stress. The Chair suggested adding this to the list of advice about future research. One of the authors pointed out that because there are huge knowledge gaps (sex ratios, life history parameters) about Offshore Killer Whales it makes looking for indicators of nutritional stress harder. Huge assumptions need to be made to apply what's known about residents to offshores.

DISCUSSION RELATED TO REVIEW OF THE DRAFT SCIENCE ADVISORY REPORT

Under the section on Species Biology and Ecology there should be mentioned made of the consequences of large group size. This increases vulnerability to impacts from such things as oil spills or noise effects because as much as 1/3 of the population can be exposed at once. Under the section on Date Sources there should be some clarification about "primary" data and "supplemental" data. Clarify the different contributions made by photo-identification data and acoustic data and that these data sources are valuable for different things. Under Population Status Trends and Recovery Targets, clarify that there are no rescue populations. There is the possibility of inbreeding depression because of the small gene pool, however, like residents there are likely behavioural elements that lead to effective outbreeding. With regard to recovery targets, it should be emphasized that it is important that the range of this population does not become restricted and further that the current recovery targets with respect to distribution may need to be revised. Under the section Distribution, Seasonality and Foraging Ecology it was suggested that it would be better to focus on the observed habitat use and not make broad statements about habitat and avoid words like "primary". It was suggested also that DFO Science staff with expertise about sharks should also be asked to review the SAR. There was considerable discussion about the Potential Threats section that also related directly back to the same content in the research document. It was suggested that tooth wear may represent a natural limiting factor and should be included. Also that group size is a factor that influences the

significance of threats since as much as 1/3 of the population can be exposed to a threat at any one time. Also some prey species may be depleted. For example could Basking Sharks have been prey? There is a need to examine trends in detail on shark species abundance. There was discussion of underwater noise. The authors agreed to distinguish different types of mid frequency sonar in the research document and the SAR because it was decided that "mid-frequency" sonar was too broad a term. One participant however also pointed out that the lack of predictability of sonar use may also be part of its threat. The discussion concluded with the authors willing to try to describe better the sound sources rather than mid-frequency sources. One participant noted that the two examples of effects of "mid-frequency" sonar involved US military ships not Canadian ones. There was also concern expressed about the need to clarify the extent of mid-frequency use by the military. It was suggested that a qualitative estimate could be provided by the DND representative. There was also a desire to see something about actions – what is or could be done under each potential threat. With respect to noise it was also pointed out that it is not only the Offshore Killer Whales that may be affected by noise but also their prey and thus this would constitute an effect on Offshore Killer Whale habitat.

There was discussion as to whether Potential Biological Removal (PBR) was an appropriate model to use to estimate allowable harm for a species with a stable population. At the very least the Recovery Factor should be 0.3 or even 0.2. It was pointed out that one could consider the Offshore Killer Whales data rich in which case one would need to do a risk assessment, or data poor – as has been done and use PBR which is conservative. However the initial point was that PBR is not even appropriate for a stable population and such a small population. It was suggested and agreed that the authors keep PBR but use one of the lower Recovery Factors, present the PBR value but indicate that there should be zero allowable harm for this population because of uncertainty in the population estimate. Under the section Sources of Uncertainty, greater clarification is needed to understand the implication of unnamed animals to the population estimates. There is uncertainty around threats and effects to individuals and to habitat. The lack of listing of this ecotype in the US could also be a threat. Lack of historical information about Offshore Killer Whales – how big was the population before the 1990s? Similarly there is lack of historical information about prey. Finally it was noted that threats that have been identified are the threats in Canadian waters.

CONCLUSIONS/RECOMMENDATIONS

The following are some concluding points identified during the meeting to be captured in the draft Science Advisory Report.

- Increased acoustic monitoring in continental slope areas, areas that may be important to Offshore Killer Whales.
- Increase acoustic data analysis effort of existing data should also be emphasized.
- Analysis of shark catch data from all sources synoptic and groundfish catch data sources is needed to better understand distribution of these potential prey and their importance to Offshore Killer Whales. It would also help to understand changes in abundance of these species prior to 1990s.
- More study for implications of early toothwear on population size, social organization, diet, survival rates.
- Continued efforts to obtain photo-identifications and biopsies from Offshore Killer Whales. These will inform population estimates, and survival and mortality estimates.

- Continued efforts to obtain prey fragment samples and fecal samples to determine diet in different seasons.

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APPENDIX 1 AGENDA

Regional Advisory Process (RPR)

Centre for Science Advice Pacific

AGENDA

Recovery Potential Assessment for Offshore Killer Whales

May 27th-28th, 2013

Pacific Biological Station

Nanaimo, British Columbia

Chair: Linda Nichol

Day 1 – Monday May 27th		
9:30	Welcome, Introductions, Review Agenda & Housekeeping	Linda Nichol
9:45	CSAS Overview & Meeting Procedures	Linda Nichol
10:00	SARA Recovery Planning	Jonathan Thar
10:30	***Break***	
10:45	Presentation of Working Paper	John Ford
11:30	Reviewer #1 comments & Author Response	Linda Nichol
12:00	***Lunch Break***	
1:00	Reviewer #2 comments & Author Response	Linda Nichol
1:30	Group Discussion to review working paper	RPR Participants
2:15	***Break***	
3:00	Discussion	RPR Participants
4:00	***Adjournment***	

Day 2 – Tuesday May 28th.		
9:00	Welcome, Introductions, & Housekeeping	Linda Nichol
9:15	Review of Day 1 discussion	Linda Nichol
9:30	Group Discussion to identify Issues and Topics needing further discussion	RPR Participants
10:30	***Break***	
10:45	Review of Science Advice Report	RPR Participants
12:15	***Lunch Break***	
1:15	Review of Science Advice Report	RPR Participants
2:30	***Break***	
2:45	Review of Science Advice Report	RPR Participants
4:00	***Adjournment***	

APPENDIX 2 LIST OF INVITED PARTICIPANTS

Last Name	First Name	Affiliation	Attend Day 1	Attend Day 2
DFO REGIONAL STAFF				
Stredulinsky	Eva	DFO Science CRP	P	P
Ford	John	DFO Science CRP	P	P
Thar	Jonathan	DFO SARA-FM	P	P
Nichol	Linda	DFO Science CRP	P	
Hargreaves	Marilyn	DFO Science CSAP	P	P
Cottrell	Paul	DFO FM	P	P
Abernethy	Robin	DFO Science CRP	P	
Macconnachie	Sean	DFO Science	P	P
Vagle	Svein	DFO IOS	P	
Ellis	Graeme	DFO Science CRP	P	P
Lee	Tatiana	DFO PICFI (SARA-FM)	P	
Pilkington	James	DFO Science CRP	P	P
Sandgathe	Tracey	DFO-SARA-EMB		
Thornton	Sheila	DFO SARA-FM	P	P
King	Jackie	DFO Science		
Spaven	Lisa	DFO Science CRP		
Ross	Peter	DFO Science IOS		
McFarlane	Sandy	DFO Science Emeritus		
Sohn	Howsun	DFO Science CRP	P	P
OUT-OF-REGION DFO STAFF				
Ferguson	Steve	DFO Science C&A	P	P
Lesage	Veronique	DFO Science IM-L		
Lawson	Jack	DFO Science NAFC		
OTHER FEDERAL DEPARTMENT REPRESENTATIVES				
Smith	Danielle	DND	P	P
EXTERNAL AGENCIES AND INDIVIDUALS				
Barrett-Lennard	Lance	Vancouver Aquarium	P	P
Yurk	Harald	SMRU	P	P
Raverty	Stephen	BC. Min. Agriculture	P	

P = present

Reviewers for the Centre for Science Advice Pacific (CSAP) working paper

Last Name	First Name	Affiliation
Lawson	Jack	DFO Science Newfoundland
Barrett-Lennard	Lance	Vancouver Aquarium, Vancouver, British Columbia

APPENDIX 3 TERMS OF REFERENCE

Recovery Potential Assessment Offshore Killer Whale

Regional Peer Review - Pacific Region

May 27-28, 2013

(Pacific Biological Station, Nanaimo BC)

Chairperson: Linda Nichol

Context

When the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) designates aquatic species as threatened or endangered, Fisheries and Oceans Canada (DFO), as the responsible jurisdiction under the *Species at Risk Act* (SARA), is required to undertake a number of actions. Many of these actions require scientific information on the current status of the species, population or designable unit (DU), threats to its survival and recovery, and the feasibility of its recovery. Formulation of this scientific advice has typically been developed through a Recovery Potential Assessment (RPA) that is conducted shortly after the COSEWIC assessment. This timing allows for the consideration of peer-reviewed scientific analyses into SARA processes including recovery planning.

Offshore Killer Whales were assessed by COSEWIC as Threatened in November 2008, and listed under SARA in July 2011. Consequently, a Recovery Strategy is to be developed by July 2013. A DFO recovery team has been struck to develop the Recovery Strategy, and a Technical Workshop to complement the development of that document was help in March 2013. No prior RPA or critical habitat assessment or analysis has been conducted.

In support of the recovery of Offshore Killer Whales by the Minister, DFO Science has been asked to undertake an RPA, based on the National Frameworks (DFO 2007a and b). The advice in the RPA may be used to inform both scientific and socio-economic elements of the listing decision, as well as development of a Recovery Strategy and action plan, and to support decision-making with regards to the issuance of permits, agreements and related conditions, as per section 73, 74, 75, 77 and 78 of SARA. The advice generated via this process will also update and/or consolidate any existing advice regarding this species.

Objectives

- To assess the recovery potential of Offshore Killer Whales.

Assess current/recent species/ status

1. Evaluate present status for abundance and range and number of populations.

2. Evaluate recent species trajectory for abundance (i.e., numbers and biomass focusing on matures) and range and number of populations.

3. Estimate, to the extent that information allows, the current or recent life-history parameters (total mortality, natural mortality, fecundity, maturity, recruitment, etc.) or reasonable surrogates; and associated uncertainties for all parameters.

4. Estimate expected population and distribution targets for recovery, according to DFO guidelines (DFO 2005).

5. Project expected population trajectories over three generations (or other biologically reasonable time), and trajectories over time to the recovery target (if possible to achieve), given current parameters for population dynamics and associated uncertainties using DFO guidelines on long-term projections (Shelton *et al.* 2007).

6. Evaluate **residence requirements** for the species, if any.

Assess the Habitat Use

7. Provide functional descriptions (as defined in DFO 2007b) of the required properties of the aquatic habitat for successful completion of all life-history stages.

8. Provide information on the spatial extent of the areas that are likely to have these habitat properties.

9. Identify the activities most likely to threaten the habitat properties that give the sites their value, and provide information on the extent and consequences of these activities.

10. Quantify how the biological function(s) that specific habitat feature(s) provide to the species varies with the state or amount of the habitat, including carrying capacity limits, if any.

11. Quantify the presence and extent of spatial configuration constraints, if any, such as connectivity, barriers to access, etc.

12. Provide advice on how much habitat of various qualities / properties exists at present.

13. Provide advice on the degree to which supply of suitable habitat meets the demands of the species both at present, and when the species reaches biologically based recovery targets for abundance and range and number of populations.

14. Provide advice on feasibility of restoring habitat to higher values, if supply may not meet demand by the time recovery targets would be reached, in the context of all available options for achieving recovery targets for population size and range.

15. Provide advice on risks associated with habitat “allocation” decisions, if any options would be available at the time when specific areas are designated as critical habitat.

16. Provide advice on the extent to which various threats can alter the quality and/or quantity of habitat that is available.

Scope for Management to Facilitate Recovery

17. Assess the probability that the recovery targets can be achieved under current rates of parameters for population dynamics, and how that probability would vary with different mortality (especially lower) and productivity (especially higher) parameters.

18. Quantify to the extent possible the magnitude of each major potential source of mortality identified in the pre-COSEWIC assessment, the COSEWIC Status Report, information from DFO sectors, and other sources.

19. Quantify to the extent possible the likelihood that the current quantity and quality of habitat is sufficient to allow population increase, and would be sufficient to support a population that has reached its recovery targets.

20. Assess to the extent possible the magnitude by which current threats to habitats have reduced habitat quantity and quality.

Scenarios for Mitigation and Alternative to Activities

21. Using input from all DFO sectors and other sources as appropriate develop an inventory of all feasible measures to minimize/mitigate the impacts of activities that are threats to the species and its habitat (steps 18 and 20).

22. Using input from all DFO sectors and other sources as appropriate develop an inventory of all reasonable alternatives to the activities that are threats to the species and its habitat (steps 18 and 20).

23. Using input from all DFO sectors and other sources as appropriate develop an inventory of activities that could increase the productivity or survivorship parameters (steps 3 and 17).

24. Estimate, to the extent possible, the reduction in mortality rate expected by each of the mitigation measures in step 21 or alternatives in step 22 and the increase in productivity or survivorship associated with each measure in step 23.

25. Project expected population trajectory (and uncertainties) over three generations (or other biologically reasonable time), and to the time of reaching recovery targets when recovery is feasible; given mortality rates and productivities associated with specific scenarios identified for exploration (as above). Include scenarios which provide as high a probability of survivorship and recovery as possible for biologically realistic parameter values.

26. Recommend parameter values for population productivity and starting mortality rates, and where necessary, specialized features of population models that would be required to allow exploration of additional scenarios as part of the assessment of economic, social, and cultural impacts of listing the species.

Allowable Harm Assessment

27. Evaluate maximum human-induced mortality which the species can sustain and not jeopardize survival or recovery of the species.

Expected publications

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

Participation

- Pacific Regional DFO Branches (Science, SARA-FM, SARA-EMB, FM, EMB, C&P, IOS)
- National DFO Sectors (NMMPRC)
- Other DFO Regions (C&A, NAFC, IM-L)
- Parks Canada
- Transport Canada
- Department of National Defence
- US NOAA
- Vancouver Aquarium
- Academia
- Non-governmental organizations
- Other Stakeholders

References

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Shelton, P.A., B. Best, A. Cass, C. Cyr, D. Duplisea, J. Gibson, M. Hammill, S. Khwaja, M. Koops, K. Martin, B. O'Boyle, J. Rice, A. Sinclair, K. Smedbol, D. Swain, L. Velez-Espino, and C. Wood. 2007. Assessing recovery potential: long-term projections and their implications for socio-economic analysis. DFO Can. Sci. Advis. Sec. Res. Doc. 2007/045.

APPENDIX 4 WORKING PAPER SUMMARY

Ford, J.K.B., Stredulinsky, E. H., Ellis, G. M., Durban, J.W., Pilkington, J.F. 2013. Offshore Killer Whales in Canadian Pacific Waters: Distribution, Seasonality, Foraging Ecology, Population Status and Potential for Recovery. DFO Can. Sci. Advis. Sec. Res. Doc. 2013/nnn.

In 2011, Offshore Killer Whales off Canada's Pacific coast were uplisted to Threatened from Special Concern under the Species at Risk Act. With this uplisting, it is required that a recovery strategy be prepared by DFO to facilitate recovery. Here, we present an assessment of the distribution, seasonality, foraging ecology and population status of Offshore Killer Whales (OKWs), as well as an assessment of the recovery potential of the population. This document is intended to support the development of goals and objectives in the future recovery strategy. For this assessment, we used an archive of observations and photo-identifications of individual OKWs collected during 137 encounters between 1988 and 2012, as well as detections of OKWs from a network of underwater acoustic stations during 2006–2012. The OKW population ranges widely in continental shelf waters from southern California to the eastern Aleutian Islands, and may occur in Canadian Pacific waters in any month of the year. Recent evidence suggests that this population feeds primarily on sharks, although some teleost fishes such as Chinook Salmon and Pacific Halibut are also consumed. To assess abundance and trends, we applied a 'mark-recapture' approach to the analysis of the photo-identification dataset using Bayesian modeling framework. These analyses indicate that the OKW population is small, with an average annual abundance estimate of 300 (95% Highest Posterior Density Interval (HPDI) = 257–373). The population appears stable, with average annual survival rates of 0.98 (95% HPDI = 0.92–0.99) balanced by annual recruitment rates of 0.02 (95% HPDI = 0–0.07). A recovery potential assessment is provided that identifies threats to OKWs and their habitat, and measures to mitigate these threats. A Potential Biological Removal (PBR) of .55 animals/year suggests that the population could sustain very little human-caused mortality without declining.