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EVALUATION OF A PROPOSED APPROACH FOR OFFSETTING INCREASES IN UNDERWATER NOISE FROM MARINE SHIPPING, USING INFORMATION ON SOUTHERN RESIDENT KILLER WHALES

Southern resident killer whales near the shipping lanes in Juan de Fuca Strait. A containership is seen in the background. Photo by Katherine Gavrilchuk, DFO.

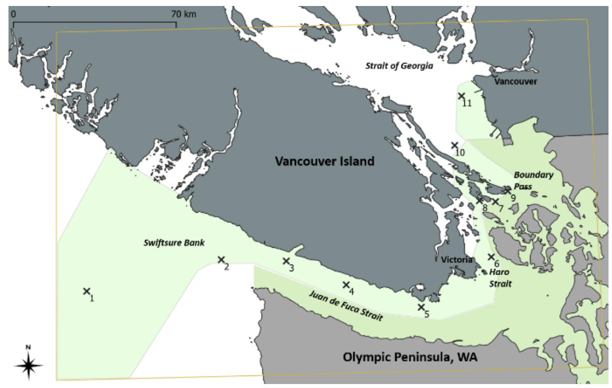

Figure 1. Map of study area. The location of eleven acoustic recorders whose data were used in the test case are indicated with an 'x' and a number. The yellow line indicates the extent of the study area, defined by the boundaries of the acoustic model. Green areas are designated critical habitat for southern resident killer whales.

CONTEXT

In 2019, the Canada Energy Regulator (CER, formerly the National Energy Board) recommended that the Governor in Council (GIC) develop an Offset Program to offset increases in underwater noise from marine shipping associated with the Trans Mountain Expansion (TMX) project and reduce adverse effects on at-risk marine species, including the Southern Resident Killer Whale (SRKW). In response to the CER's recommendations, the GIC committed to continue to support and implement noise management measures that would help address effects on the SRKW, and to monitor and adaptively manage these measures.

To support this commitment, Fisheries and Oceans Canada (DFO) Fish and Fish Habitat Protection Program (FFHPP) developed a noise offset framework in an attempt to apply an evidence-based, scientifically robust, quantitative method to determine the extent that shipping noise from major development projects could be offset through management measures. DFO's Ecosystems and Oceans Science sector supported the development of this framework through the implementation of a comprehensive SRKW noise monitoring program in the TMX marine shipping area to achieve the following:

1. establish an underwater noise baseline,

2. support the development of an underwater vessel noise model to predict increases in noise levels from project related vessels, and
3. evaluate the effectiveness of specific underwater noise management measures.

The development of the noise offset framework was informed by the guiding principles of biodiversity offsetting and previous science advice that recommended aiming for a no-net increase in noise from project-related shipping. The framework was further informed by the outcomes of a workshop with DFO Science subject matter experts in 2021. As the framework is a novel potential tool, FFHPP has requested that DFO Science review and evaluate the following components of the framework and how they would be applied in a case study using projected increases in underwater noise from TMX-related vessels in the Salish Sea and the potential impact on the SRKW:

- **Spatial and temporal boundaries:** The methods used to determine the spatial and temporal boundaries of the framework,
- **Noise baseline:** Noise levels prior to implementing management measures to address project impacts and prior to project-related marine shipping,
- **Incremental project noise:** Noise levels contributed by the additional marine shipping associated with a major project,
- **Management measures:** Means to measure changes in noise levels resulting from the implementation of underwater noise management measures,
- **Offset ratio:** Defining a species-specific multiplier that establishes habitat equivalency by weighing impacted habitat based on use and/or frequency of occurrence of the species of interest,
- **Application of offsets:** The approach to applying offsets to counterbalance a noise increase from project-related shipping in one area and/or time period with a noise reduction from measures in another area and/or time period.

This Science Advisory Report is from the March 12-14, 2024, national peer review on the Evaluation of a Framework for Offsetting Increases in Underwater Noise from Marine Shipping Associated with Major Development Projects: A Case Study Applying a Noise Offset Framework to the TMX Project and its Impact on the Southern Resident Killer Whale. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

SUMMARY

- Offsetting is a management tool applied to address habitat impacts that are not fully mitigated by other actions.
- A proposal to offset anticipated increases in underwater noise was developed by Fish and Fish Habitat Protection Program (FFHPP, the client), with application to TMX vessel-related underwater noise in relation to southern resident killer whales (SRKW).
- Advice was sought on the exchange of offset credits, which are defined both spatially and temporally. This included: the use of sub-regions for credit exchange; the formation of a baseline, and calculation of changes in sound levels resulting from project-related vessels and mitigation actions; the use and calculation of weighting factors to express variable habitat importance to focal species; and the principles guiding credit exchange as part of offsetting.

- The application of offsetting to address underwater noise is unprecedented and complex. Such an approach has potential value for addressing underwater shipping noise, but is data intensive, and is not recommended in data-poor settings.
- Challenges and methodological concerns were identified in the applicability and effectiveness of the proposed approach as a management tool. While the analysis completed could inform the choice of mitigation measures, additional work is required before proceeding with implementation of the proposed noise offsetting approach (including for TMX and SRKW), due to large uncertainties that have been identified.
- Offsetting should be constrained by the area of occupancy of the focal species and occur in spatial and temporal proximity to noise increases. Comparability in the importance and type of the habitat to the focal species is required when considering credit exchange; however, the criteria for biological equivalency were not agreed upon.
- The proposed sub-regions for offsetting credit exchange in the test case were not agreed upon, and contributed to the rejection of the approach. Suggestions were provided for a more rigorous approach to spatial subdivision.
- Refinements to the vessel noise model presented in the test case were suggested. Careful consideration of the selection of sound level metrics, appropriate frequencies, source levels, and propagation assumptions is required, including spatial and temporal considerations.
- Reservations were expressed regarding the identification, calculation, and exchange of offsetting credits. As presented, the use of offset credits was rejected, and improvements were suggested to support future considerations.
- Participants agreed that consideration of a multiplier or risk factor (the ratio between the impacted and compensated habitat) may be applied as a management tool to capture uncertainties of the proposed approach, any periods of time without offset, or any other relevant considerations.
- The baseline should be established to represent a period in time prior to project operations, and prior to implementation of project inputs, mitigation measures, and offsets, consistent with the principle of additionality.

INTRODUCTION

Offsetting aims to address unavoidable loss or degradation of habitat resulting from anthropogenic activity by countering it with improvements, creation, or restoration of habitat in adjacent or nearby areas. Offsetting is considered when residual adverse effects are expected after all efforts have been exhausted to first avoid or subsequently reduce or mitigate impacts from project-related activities. Offsetting residual impacts by creation or restoration of habitat of equivalent value elsewhere (e.g., spawning grounds for fish), or by reducing impacts from non project-related activities can help achieve a no-net loss in biodiversity or habitat. The effectiveness of offsetting is estimated through the use of credits, which must be replicable and robust in their calculation, and represent the same metric or currency for exchange between spatial regions and/or temporal periods. In exchanging credits, the aim would be to achieve at least no overall effect or impact.

The concept of offsetting has been applied globally, for example for carbon offsetting, but never before been used to address underwater noise from marine shipping related to major development projects. DFO Science was asked to evaluate how an offsetting approach could be applied to address incremental increases of underwater noise from vessels related to major development projects and their impact on at-risk species, and assess the risks and uncertainties in doing so. Components of a proposed framework developed by FFHPP were evaluated using data from southern resident killer whales (*Orcinus orca*, SRKW) as a test case. Advice was sought on the proposed framework and its application (Figure 2), including the spatial and temporal aspects of credit calculation and exchange, including the use of sub-regions; the methods and metrics used to quantify an underwater noise baseline level; the use and weighting factors or offset ratios in credit calculations, to express aspects of habitat importance and variable use by the focal species; and the principles guiding credit exchange, such as the amount of compensation required given the likely efficiency of compensatory measures and how to define equivalency in habitat regions.

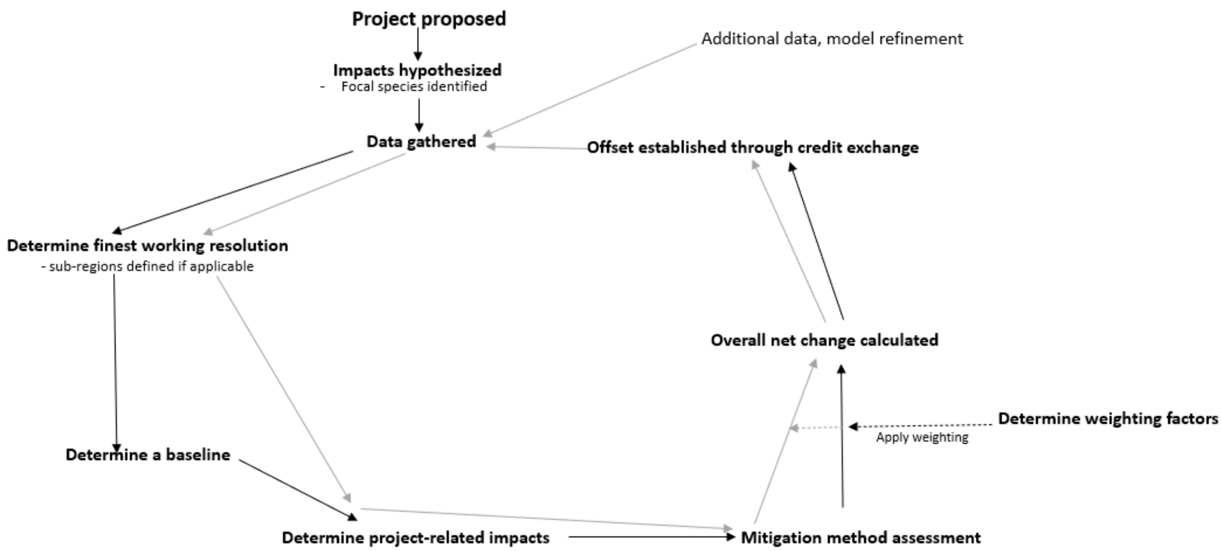

Figure 2. Schematic of the proposed offsetting process (black arrows) with future iterations and means to add more data as it becomes available indicated with grey arrows.

The potential of offsetting as a means to counter project-related impacts was recognised by participants in the review of the proposed framework and test case example, however it was agreed that its application to underwater project-related noise is premature, with no consensus reached on how the approach may be used at this time. Many uncertainties and data deficiencies were identified, highlighted by the use of the SRKW test case. Due to high levels of uncertainty with the application of the proposed framework to the test case, it was concluded that at this time offsetting should not be used to address project-related impacts to SRKW. The discussions for each aspect of the proposed framework (Figure 2), the identified risks and uncertainties, and suggested improvements, where appropriate, are detailed below.

The application of the theoretical proposed framework to at-risk species was demonstrated through the test case. SRKW are listed as endangered under the *Species at Risk Act,* with 74 individuals as of January 2024 (CWR 2024). Areas of the Salish Sea, Juan de Fuca Strait, and Swiftsure Bank have been designated as critical habitat (CH) for SRKW (Figure 1). Presence of SRKW in this area is elevated between May and October, and is strongly correlated with the spawning migrations of Chinook salmon (*Oncorhynchus tshawytscha),* their preferred prey. The test case was restricted to this six-month period, even though the population is known to occur in portions of their critical habitat outside of this time. Winter data on SRKW presence and habitat use are currently limited.

The offsetting approach was considered for incremental noise increases from TMX tankers and escort tugs transiting through the Salish Sea, which are expected to increase from five to thirty-four transits per month. The CER concluded that the SRKW population has crossed a threshold where any additional environmental impact or disturbance would be considered significant, and without further mitigation the TMX project is likely to result in significant adverse effects on SRKW. The offsetting strategy applied for the test case is to counterbalance the expected TMX project noise increases with decreases from management measures applied to other large commercial vessels. The CER was of the view that because cumulative effects are already causing significant adverse effects on SRKW, measures applied to only TMX-related vessels would not be sufficient to address and mitigate project effects. A slowdown of all vessels was therefore considered as part of the offsetting assessment.

ASSESSMENT

The data needed to develop an offsetting approach and the proposed framework were discussed, including the limits and caveats in its application.

Consensus was reached that the spatial and temporal aspects of applying offsetting should be defined by the presence and habitat use of the focal species. Species presence data was recommended as the minimal data requirement for the development and application of an offsetting approach. Therefore, the study area proposed for offsetting in the Salish Sea and surrounding waters incorporated areas of known SRKW presence and critical habitat (study area; Figure 1). Information on SRKW habitat use, obtained from dedicated and opportunistic surveys in the study area, was modelled to predict frequency of occurrence and identify foraging locations. Passive acoustic recordings from eleven locations throughout the study area (Figure 1) were collected to inform these analyses.

A vessel noise model was also used to interpolate between these mooring locations and allow soundscape comparisons through time and vertical and horizontal space (i.e., through the water column). Inputs to the model included Automatic Identification System (AIS) vessel tracking data, oceanographic variables to define the sound speed field, sediment characterisation and geoacoustic properties to account for transmission losses, source-level data to quantify vessel noise emissions, and acoustic frequency-dependent water absorption. The *in-situ* recordings were used to validate the model outputs, comparing sound levels of the same frequency, depth, and time.

A key tenet of offsetting is the exchange of credits by counterbalancing habitat losses and gains from measures within and between sub-regions or time periods. While the definition of relevant temporal units for credit exchange were not discussed during the review, two approaches of sub-dividing the study area were compared as part of the test case, with much more effort given to the discussion of spatial exchange of credits. The first used acoustic mooring data to delineate sub-regions with similar soundscape characteristics, while the second considered SRKW frequency of occurrence data and locations of key foraging areas. Meeting participants indicated a strong preference for the species-centric approach, using animal presence and habitat use data to define sub-regions and assess relative importance. However, it was stressed that care be taken when outlining sub-regions so that the importance of each sub-region to the focal species is not diluted by being too broad or impacted by the variability of use. Participants agreed that the sub-regional boundaries set forth in the draft test case did not account for this concern. In addition, the resolution of the sub-divisions was discussed, with agreement that the finest scale of data available should be used to characterise the soundscape changes, estimate habitat importance (weighting factors) and calculate credits for exchange. However, it was acknowledged that coarser sub-region divisions may be necessary for more data-limited applications, with the caveat of this likely increasing uncertainty in impacts/credit estimation. Issues such as movements of animals between sub-regions (including movement corridors) and the propagative nature of underwater sound within and between regions were mentioned in reference to the definition and use of study area sub-divisions, however there was no definitive resolution of how this could be addressed or accounted for when calculating the offset.

Noise additions from project-related vessels and noise reductions from management actions were calculated in reference to an acoustic baseline. There was agreement that a conceptual baseline should represent a time period prior to project-related operations, and prior to implementation of project-related inputs and mitigation or offset management measures, to be consistent with the principle of additionality (Gillenwater 2012). This principle is common to biodiversity offsetting, which holds that actions taken under the offsetting efforts must provide a conservation benefit that would not otherwise have occurred. In accordance with the principle of additionality, this means that the management actions taken to counter project-related impacts under the offset approach should exceed any conservation measures that may already be in place in the study area (IUCN 2016).

Consensus was not reached with regards to the proposed choice of baseline year for test case. Presented to participants for review was data from 2015, which predates project approval for TMX. Some participants, however, noted that a baseline closer to initiation of project operations and vessels sailing would be more appropriate, with the first TMX-transits in May 2024. Baselines using data from 2017 onwards would need to reflect existing conservation measures for SRKW in the Salish Sea, including increasing approach distances and vessel slowdowns, rerouting and exclusions. The divergent views were acknowledged in the meeting, however the use of the 2015 baseline remained as a conceptual reference from which to estimate the theoretical TMX impact, management measure success, and the use of credits for offsetting, with the aim of achieving a zero-sum impact and overall no-net noise increase.

The project impact in each sub-region was calculated by determining where TMX vessel noise was present above the minimum ambient sound level for the baseline year through a modelled scenario. The minimum ambient sound level represents periods where vessel and abiotic (wind and wave) inputs into the soundscape are minimal, and is derived from the lowest sound levels seen over six years of recordings (2018-2024). The expected increases were calculated using the vessel noise model and synthetic AIS data to simulate the TMX-related increase in vessel traffic from baseline. In the test case, the minimum ambient sound level was applied globally across all locations. Using this as the reference point for estimating project-related impacts, it is not expected that the choice of baseline year would be influential. This may not be true if another metric was used, whereby the difference in vessel number (approximately 300 additional vessels in 2022 compared to 2015) and seasonal slowdown zones around Swiftsure Bank and through Haro Strait and Boundary Pass may influence the baseline soundscape levels from which TMX additions are considered. For the test case, the model suggested that there were few areas that would not receive additional noise inputs from TMX tankers and escort tugs, with these additions focused around shipping lanes.

The effectiveness of a management measure used to offset TMX-related noise additions was also estimated through comparison to the baseline. For the test case 2015 AIS data were used to simulate a scenario where all commercial vessels transiting through the study area were slowed to 10 knots. This exceeds any measure currently in place or previously trialed in the Salish Sea, with a greater spatial extent and requested speed reduction. In this case the extent and location of changes in sound level from baseline may differ based on the baseline year selected due to some existing voluntary slowdown measures being in place in 2022 which were not in 2015, but this comparison was not made.

Model outputs were extrapolated to frequencies that represent the communication calls and echolocation signals of SRKW to better assess the acoustic impact. A single aggregate metric was also calculated to represent the changes over the full SRKW acoustic repertoire. Call parameters were defined from previous research, although it was acknowledged that the hearing range, or range of frequencies that SRKW might be sensitive to, may be wider than the frequency range used for calls and clicks. Changes in sound levels were examined at typical swimming and diving depths for SRKW, as determined from data from biologging studies (7.5, 50, and 100 m). Questions were raised about the adequacy of the sound level metrics used to represent the finer temporal changes of acoustic habitat and estimations of impact to SRKW, rather than, for example, the gains and losses in relative ‘quiet time’, or the use of masking metrics. These were suggested as a possible future refinement of the offsetting calculations. Notwithstanding these concerns, for this first exploration of offsetting the median sound level (L_{50}) over 6 months was used in the credit calculations to represent the soundscape experienced by SRKW for at least 50% of the time, and be less influenced by extreme additions as the mean (L_{eq}) might be. Changes in sound levels for scenarios relative to the baseline (baseline plus TMX vessels, slowdown from baseline) were calculated consistently in this way to be able to be compared. The six-month scale was in line with the data available for SRKW presence and habitat use, used for sub-region definition and to form weighting factors.

The use of weighting factors in the offset calculations was explored in the test case. The inclusion of these factors allows the recognition that regions within the study area may be used differently by the focal species. It is also a means to express value or equivalency in habitat use and importance to the focal species of each sub-region or spatial unit. Sub-region weighting factors in the test case were assigned using the mean probability of SRKW occurrence and the likelihood of common and frequent foraging as indices of habitat value. Again, it was agreed that the weighting factors should be applied at the finest spatial and temporal resolution possible, potentially negating the need for sub-regions. In the test case, a value was assigned to regions in critical habitat, as well as a value to represent relative occurrence of SRKW and if the area is part of known foraging regions. The values for each were calculated as additive, but refinements and other means to calculate or represent habitat value were discussed as part of the test case review. Concerns were raised over the arbitrary definition and values of the weighting factors used in the test case, as well as their additive nature, which could allow offsets to be made in areas outside habitat used by SRKWs. It was suggested that any variables used for weighting should be multiplicative, rather than additive, to reduce the chances that similar weightings could be achieved but not represent equivalency in habitat. It was also suggested that the final functions should range between 0 and 1 would be a marked improvement, and be more consistent with the use of weighting functions more generally. However, no consensus was reached over exactly how to best calculate weighting factors, especially if drawing on more than one data set, and where the data have differing spatial extents.

If average weighting factors were to be applied to sub-regions, then it was suggested that a measure to represent the variability or distribution of values within the region should also be included. A kurtosis calculation or similar was proposed; however, an acceptable range or deviation in this value that would still allow for habitats to be deemed equivalent was not agreed upon. It was noted that the calculation of weighting factors using this mean values approach could result in misrepresentation of the importance of the area depending on the size of the sub-region and the distribution of values within it, and so care in defining sub-regions was also stressed.

Principles to guide credit exchange were discussed, but not conclusively agreed upon. There was agreement that they should ideally be ‘like-for-like’ i.e., being of similar value and benefiting the same segment(s) of the population, and based on distinct features that support animal presence and habitat use. Where possible, decisions should also consider the number and the residency time of animals using the area. Great uncertainty was expressed in how weighting factors may be calculated and applied to the credit calculations, and how these factors would be used to identify habitat of equal quality and ensuring 'like-for-like' exchange. The derivation of weighting factors represents a key assumption within the proposed framework. Extra consideration in determining equivalency should be given to populations that are age- or gender-segregated. In some situations, there may be merit in excluding specific highly-valued areas from the credit exchange. For example, it was suggested that areas providing habitat for vital behaviours or those that are unique in the ability to support portions of the population (e.g., for weaning) could be excluded and only targeted for sound-level reductions.

Participants agreed that the scale of the credit calculation and exchange should represent something biologically meaningful to the focal species. However, allowances in the rate (e.g., 1:1 credit exchange or other), and span of space, time, and behavioural context across which credits may be exchanged, and the permissible deviations of these allowances were not defined. Also, the incorporation of the temporal aspects of credit calculation, weighting factor determination, and credit exchange were discussed in much less detail than the spatial aspects, and not resolved. In theory, offsetting could be applied to periods proximal in time, but uncertainty about how this might be calculated, as well as about the values for the thresholds in exchange were high (i.e., how numerically close the weighting factors need to be to achieve 'like-for-like'). Currently, the test case presents data for the full six-month summer period where SRKW presence is greater in the study area, and does not incorporate variation in relative presence or habitat use on a finer temporal resolution. It also does not extend to the winter period (November-April), despite project-related vessels transiting year-round and whales occurring at times in portions of the study area during those months. This winter period was considered to be data poor, with insufficient data on whale presence and habitat use to accurately apply the offsetting framework.

The test case showed that the proposed offsetting approach was data-intensive. Therefore, the consensus view was that it should not be applied to data-limited species or populations. Minimum requirements for data were discussed, including knowledge of the focal species presence and habitat use over space and time, but other needs were not conclusively captured. It was agreed that spatially explicit offsetting, with exchanges of noise reductions and gains among regions and sub-regions, would not be a viable approach for many species and habitats, where sufficient data were not available. Even for the SRKW test case, it was considered that sub-region definition and weighting factors could not be established reliably due to a lack of sufficient area covered by the behavioural data used to define foraging regions. This may limit the feasibility of using a 'like-for-like' approach in credit exchange or the proposed propose framework altogether. Uncertainty in the values assigned to lower-use areas of critical habitat, or areas that extended past the extent of the foraging model, contributed to this. Significant discussion was centred on how to express the inherent variability and uncertainty in the empirical and/or modeled data needed for the approach, and how to resolve it in credit calculation, weighting, and exchange. Offset systems account for uncertainty by employing a 'multiplier', an additional variable in the credit calculation. Often offsetting must achieve an overall benefit that is a multiple of the conservation, biodiversity or habitat loss, with the size of the multiplier in this calculation reflecting the degree of uncertainty or variability, along with other factors that could diminish benefit. Participants did not discuss the size of the multiplier to be applied in the test case, or how a multiplier could be used to be a reflection of the uncertainties discussed. However, it was stressed a variable like this in the credit calculation should be considered to account for variety and the uncertainties encountered in the review, and the novelty of using biodiversity offsetting for underwater noise.

Sources of Uncertainty

Vessel noise modeling

The vessel noise model used in the test case was validated through comparison to recordings made at eleven locations throughout the Salish Sea (Figure1), but further refinements may be warranted. The model was found to consistently underestimate sound levels compared to the field recordings made at the same time frame, depth, and frequency, highlighting the need for *in-situ* data as well as modelled results when considering an offsetting approach. Discrepancies were at their greatest in enclosed waterways and areas with acoustic barriers such as intervening topographical features. This may be because not all vessel presence is included in the model, with smaller commercial and recreational vessels not required to make AIS transmissions and therefore were not registered or used as model inputs. There is some uncertainty in the model inputs, not least the data used to characterize the source levels of noise emissions from vessels. The catalogue of vessel source levels is relatively limited, despite it being known that there is notable variability between vessels. Model sensitivity testing to input variables, especially source levels, is ongoing. The model will be updated to include the specific source levels of TMX vessels once they have been established from field recordings. Uncertainty is also introduced by using the frequency ranges representative of SRKW communication calls (500-15,000 Hz) and echolocation (15-100 kHz) signals. Improvements to the model are under way to allow for direct modelling of the higher frequencies rather than using extrapolation from a low-frequency output, which participants suggested would improve the estimations of sound level change, and so credit calculations for offsetting.

Habitat use modeling

Limitations in available SRKW behavioural data meant that a large portion of the study area was out of bounds of the foraging model from which the offset weighting factors were derived. Only areas on Swiftsure Bank and Haro Strait (see Figure 1) were modelled for their use as foraging locales, leaving much of the study area deficient of a value in the weighting factor calculations. This means that potential foraging regions in the study area may have been overlooked, or importance of regions in the study area underestimated. The knowledge of SRKW presence and habitat use is at its greatest for the months of May to October, with much less known for their winter presence, and so the application of the proposed offsetting framework has so far been limited to the summer months. The inclusion of variables that could act as behavioural proxies, such as prey presence as an indicator for foraging regions, were discussed, but they are also data limited at this time. The calculation of weighting factors was an area of great discussion for participants, with data limitations leading to uncertainties in the calculation and application of these factors to accurately represent habitat importance, and the biological relevance of each region to the focal species. Not using sub-regions, and instead working at the finest resolution of available data, would remove some of the variability and uncertainty when assigning sub-region habitat valuations, and remove the need to test for potential dilution of habitat importance or the inclusion of a statistical representation of value distributions. For the test case, the minimum spatial resolution would be defined by the resolution of the vessel noise model expressed at the same output spatial scale as the behavioural data models, and so the output resolution for the frequency of occurrence and habitat use models. This would allow for habitat equivalency and changes in noise levels to be considered for area units of several kilometres squared throughout the study area, rather than more broadly defined sub-regions.

Expressing habitat equivalency

Limitations and uncertainties in the data needed to define habitat equivalency in time and space for the focal species were discussed at length, especially in regard to credit calculation and exchange. Ensuring that the biological relevance and/or importance of the area to the focal species is expressed and not diluted during the credit calculation process, particularly if done through the use of sub-regions, was stressed throughout the review. Habitat equivalency and the exchange of credits between similar areas, should draw on a number of variables that underlie the focal species' use of the habitat. However, the data available for the test case were not found to be rigorous nor exhaustive enough to be able to reliably outline regions of equivalency throughout the study area.

CONCLUSION

The test case was designed to help evaluate whether net increases and decreases in underwater noise may be monitored and repeatedly calculated to establish credits for offsetting, using six-month median sound pressure levels and SRKW data as a means to parametrise the proposed theoretical offsetting framework. Conceptually, there was reasonable agreement that an offsetting approach could be applied as a means to address any residual project-related vessel noise increases in the context of focal marine mammal species and inform adaptive management of measures, and that the steps outlined in the test case in developing a framework were sound. However, issues remained unresolved in how the concept may actually be implemented due to the large amount of information and assumptions required for the credit calculation and exchange. As well, fully understanding any associated benefits of the application of the approach to the focal species is complex. High levels of uncertainty and risk were identified for this, especially in the derivation of species specific weighting factors.

Participants did not agree with the use of offsets to counterbalance a noise increase from project-related shipping in one area and/or time period with a noise reduction from measures implemented in another. While it can be assumed that reduction of vessel noise in the marine environment would be a benefit to species, offsetting additions in one region with reductions in another depends entirely on equivalency in the value of those habitats to the species using them, in terms of not only function (e.g., foraging), but also frequency and duration of occupancy in those areas. Participants were also hesitant to determine the level of allowable increases for at-risk species. The number of uncertainties and data limitations identified while considering the test case example was too great for participants to be comfortable that any offset approach used in an attempt to eliminate or effectively reduce impacts to SRKW would be successful and scientifically robust. Greater still were the uncertainties and risks identified in an application of the offsetting approach to other at-risk species and/or other regions. It was thought that the implementation of the proposed framework without significant refinements may lead to a false sense of security in addressing and achieving conservation goals, potentially undermining the recovery efforts aimed at at-risk species. Ultimately, neither the proposed framework nor the test case were approved by participants at this time due to the various concerns noted above. The test case only highlighted the large amount of data that would be needed for an offsetting approach, and the inherent risks and uncertainties when being applied to the proposed framework. Further data additions, model refinements and revisions to offset calculation processes were suggested as part of the review, as were alternative management measures as scenarios that may be considered if the offsetting approach is to be advanced in the future.

OTHER CONSIDERATIONS

It became clear through the review that significant refinements to both the proposed framework and the test case example would be necessary for this approach to be applied successfully and be scientifically robust. The work presented does not evaluate the effectiveness of offsetting measures in supporting species recovery, nor does it discuss species impacts, the potential for acoustic or behavioural disturbance, or physiological or energetic consequences of the addition of noise from project-related vessels. Without considering the relative level of consequence for individuals or populations from any given impact type, it is only possible to consider 'like-for-like' or areas equivalency in their use for the exchange of credits between sub-regions, as discussed above. Such an equivalency is completely dependent upon the application of a valid weighting process reflective of some heterogeneous habitat use within the boundary of any sub-region.

The proposed offsetting framework, as described, could be adapted as new data becomes available (see Figure 2). However, the integration of new data, and the rate of its inclusion, as well as the schedule of revision and monitoring of offsetting measures through credit calculation was not discussed, although a minimum of an annual review was suggested. Data that becomes available could be incorporated at these yearly markers. For the SRKW example, such information may include additional data on whale presence and habitat use, or the addition of prey data as a means to weight sub-regions and/or as a proxy for foraging in data deficient areas. As more data become available, the estimates of offset credits may be possible on increasingly finer spatial and temporal resolutions, with agreement among participants that weighting factor integration and credit calculations should be completed at the finest granularity possible. However, this may impact the number and size of regions that are deemed equivalent for credit exchange.

Inclusion of aspects relating to the changes in habitat use and sound speed profiles resulting from climate change or other variables were discussed. It remains unclear whether inclusion of these variables could make the framework more robust, and how this may be done.

While discussing the wider application of a noise offset framework, the case of a multispecies application was also presented, but there was no resolution on how the framework would be applied in this instance. The pervasive nature of sound, travelling across sub-regions differently according to signal types and oceanography, also means that the effects for different species with distinct auditory capabilities would need quantifying. Focus remained on SRKW in the frequency ranges considered for offsetting and in the data used for sub-region definition and habitat weighting factors for the test case. An extensive review of data would be needed for each application of the offsetting approach, and proposed framework outlined in the SRKW-Salish Sea test case, to other species in the same area and/or to other regions to allow the conceptual approach to be applied in the most species-specific way possible.

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