Center for Independent Experts (CIE) Independent Peer Review of the Puget Sound Nearshore Conservation Calculator and the integral Puget Sound Nearshore Habitat Values Model

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January 2024

Executive Summary

The Nearshore Calculator is a tool developed by NOAA to assess habitat credits and debits for activities that occur in the nearshore zone of Puget Sound in the Salish Sea. According to the Endangered Species Act, activities that pose a potential threat to species listed by the Act must undergo assessment. Puget Sound is heavily developed by human activity, which necessitates maintenance and occasional expansion of impact areas to support the society that has settled along the shores. These activities may affect species including listed populations of Pacific salmons and their predators, the listed population of killer whales that specialise on salmon. Activities that expand impacted areas in the nearshore zone will create habitat debits while removal of impacting structure or restoration can generate credits; for activities that create credits to be offset, a tool such as the Nearshore Calculator is required for accounting. The Calculator provides an interface that combines Habitat Equivalency Analysis with the Nearshore Habitat Values Model. Habitat Equivalency Analysis was developed to address a need to identify appropriate compensation measures for habitat that is affected by measures undertaken by proponents that positively or negatively affect habitat. However, it is noted that there is little evidence provided that Habitat Equivalency Analysis will succeed in maintaining ecological services, ecosystem services, or the conservation of species at risk. Extending HEA using the Nearshore Habitat Values Model provides a tool that assigns values to habitat types so that the Habitat Equivalency Analysis can be carried out with appropriate consideration provided to the specific habitat affected by activities within the Puget Sound nearshore. Collectively, these models form the basis of the Nearshore Calculator, which is here under review. Key assumptions of the tool are that juvenile salmonids are the only impacted life stage, that the different zones of the nearshore are exploited differently by salmonids, that actions impacting different habitat zones affect juvenile salmon differently, and that equivalent offsets nullify negative impacts of nearshore activities. There will always be shortcomings when attempting to quantify ecological metrics that are inherently dynamic in nature and have spatial and temporal dependencies that are challenging to account for. However, the Nearshore Calculator goes to great lengths to find and interpret published evidence and, in their absence, uses opinions of experts to establish a comprehensive evidence base for the tool. This expert review identified only limited shortcomings in the approach to populating the Calculator with terms following thorough scrutiny of all related documents, and a slidedeck example of practical implementation of the tool. Key recommendations are to use or develop more knowledge on the usage of the nearshore zone by juvenile and adult salmonids, especially adults, to better quantify the mortality impacts associated with habitat degradation, to consider whether evaluation of activities on the shore zone should be assessed, to use habitat maps especially of eelgrass to refine adjustment factors, and to determine whether HEA provides a sufficient framework with which to sustain ecosystem services and the needs of species at risk.

Main Body

Background

The National Marine Fisheries Service has undertaken a biological opinion according to the Endangered Species Act to assess impacts of routine activities on species at risk in the Salish Sea area, specifically salmon, bocaccio, rockfish, and killer whale. Salmon, including Chinook, migrate through the Salish Sea in large numbers as juvenile smolts and must pass through areas where activities may hinder the migration. The migration of these species is typically through the nearshore zone as they tend to follow the shoreline out of the Salish Sea to the broader Pacific Ocean where they feed and grow before returning to the home river to spawn. Marine survival of these migratory salmonids has declined, precipitating reduced abundance and overall productivity of coastal and freshwater habitats within the Salish Sea area. Modification of the nearshore zone alters productivity that lends to the availability of key forage fish species and can disrupt migration patterns of the salmon that delay migration or cause premature mortality. Chinook salmon are believed to be the primary prey of the southern resident killer whale, meaning that work impacting the nearshore zone in the Salish Sea can have secondary ecosystem impacts that must be considered. The nearshore zone within the Salish Sea is considered to extend from upland banks where shade and organic material are made available to the waters beneath down to the deepest depths of the photic zone. This can encompass a broad range of habitat types including estuary, eelgrass bed, saltmarsh, mudflat, kelp forest, rocky shore, and more.

The Salish Sea nearshore zone has a growing population that conducts work impacting the nearshore zone. Routine activities referred to and investigated as part of the program encompass dredging of sediments, construction and repair of in-water and over-water structures, and shoreline armouring along with any other activities along the shoreline zone where activities will result in damage to habitat. The present status of the nearshore zone within the Salish Sea is already considered to be “degraded”, meaning that further activity will perpetuate the state of disrepair. Already, 27% of the shoreline has undergone modification by armouring and there are >500,000 acres of overwater structures. The nearshore zone is considered critical for the migration of juvenile salmonids between their home rivers and estuaries and the open ocean where they migrate to feed. Nearshore zones are also likely used by adults that must migrate back from the ocean to the river to spawn, although this is neither mentioned nor considered anywhere in the document. The Conservation Calculator has divided the nearshore into distinct zones, being the riparian, upper shore zone, lower shore zone, and deeper shore zone.

To determine the extent of impact incurred by actions in the nearshore zone of the Salish Sea, and appropriately calculate any necessary mitigation, the Nearshore Conservation Calculator was developed as a tool. The Conservation Calculator provides a user interface that unites Habitat Equivalency Analysis and Nearshore Habitat Values Model. The Nearshore Habitat Values Model is a key input to the Habitat Equivalency Analysis that assigns values to nearshore habitat types, facilitating the Habitat Equivalency Analysis. The five nearshore zones have been assigned maximum potential values based on the potential functioning of the ecosystem under ideal conditions in each zone. Field surveys or geospatial tools are necessary to assess the condition of each zone relative to the theoretical maximum based on the habitat presently available, to determine the quality of habitat that will be lost. By filling in the Calculator, agencies and proponents can come to a common understanding of the habitat impacts

of a proposed action, identify the cost of implementation, and subsequently create a mitigation or offset plan. The Calculator can be used by proponents to prove no net loss of their proposed action.

Description of Role in Review Activities

The NMFS sought expert reviewers to provide input on the scientific basis of the Nearshore Habitat Calculator. Reviewers were sought with expertise in:

1. Salmon ecology
2. Marine nearshore ecology and conservation biology
3. Development of models preferably in the context of making decisions to avoid, minimise, or mitigate potential impacts
4. Science of valuing habitat for fishes based on ecological functions and services
5. Quantifying effects of physical changes
6. Quantifying effects of changes in habitat condition

In the following review I will provide a detailed summary according to the Terms of Reference as an expert reviewer.

Summary of Findings

1) Analytically sound process:

a) Are the underlying relationships that Nearshore Calculator and the NHVM are built upon (e.g., duration of aquatic access, functional pathways, indicators/metrics) sufficient and well-founded for evaluating effects of changes to nearshore habitat conditions on salmonids, given the stated goals and objectives?

- The approach to systematic literature searching is similar to those used in most evidence syntheses. References go beyond the basics to include not just published literature but reports, theses, and expert consultations. There does not appear to have been a critical appraisal of the literature, which is a key step in systematic reviews, but the evidence base is not stated to have been developed by systematic review and this is therefore not a limitation of the approach. Critical appraisal could in the future be considered to omit evidence that does not meet high enough standards. Overall, the relationships are considered to be reasonably well-founded in evidence.
- Underlying relationships within the Calculator have been derived from primary literature, expert consultation, and open geospatial and physical (e.g., tidal) data. The availability of comprehensive and open geospatial data for developing the tool is a great asset that has been well used. Such data are not always available for these activities, but this shows how important it is to have openly available geospatial data.
- Shore zones appear to be determined using the best available evidence and models that have been validated against observations, such as the determination of HAT from geospatial data. Flexibility has been built into the determination of shore zones to account for presence of SAV as a key indicator, making the tool adaptable, which is necessary in a dynamic environment such as a sound.
- Substitutability of habitat has not necessarily been well developed, for example the relationship between two habitats in different zones. On P13 of the main document it is

stated that riparian restoration could be an acceptable out of kind offset for loss of eelgrass, but this is not supported by evidence other than the fact that the two apparently provide somewhat comparable services. Concern that the relationship between these two habitats is not well enough developed within the documents to support that sort of substitutability and that in general there is a risk of slippage in ecosystem services where credits do not appropriately offset debits across shore zones.

- Uncertainty is quite well considered and the explanations for why decisions were made is clear. The uncertainty table (Table 6-1) was quite helpful to evaluate whether uncertainty was thoroughly considered. Uncertainty as to whether Habitat Equivalency Analysis is sufficient for the conservation goals is not assessed.
- Adjustment factors provide the basis for a robust and agile approach to creating debits and credits. Without the adjustment factors there would be a much higher level of vulnerability, so the inclusion of these factors is a huge asset.

Is the analytical approach based on a valid list of habitat attributes (physical and biological functions)?

- One key habitat attribute that seems to be missing is the actual abundance of different habitat types, especially compared to baseline values as things have surely changed quite a bit in the area. Whether a habitat is lacking or not should potentially be better quantified and this could then be integrated into the Calculator.
- Consideration of oceanographic phenomena is well represented within the nearshore calculator. An impressive level of detail is evident considering the inclusion of sea level rise and the conservative use of 2050 sea levels understanding that habitat today is more valuable than habitat in the future. There is very little evidence that Representation Concentration Pathway (RCP) 4.5 will be attained, but it is a possibility. Consideration of longshore drift and the dynamic influences of oceanographic phenomena on sediment is well explained, including within appendices.
- To determine whether the Nearshore Calculator represents the best available science, a review of the literature cited section and appendix items with expert correspondences was conducted and cross referenced with the reviewer's expert knowledge and auxiliary literature searches as a gap analysis. Where published evidence was lacking, consultations appear to provide valuable insight, including in determining duration of effects of overwater structures and armouring. Key literature cited was reviewed to check assertions and logic contained within the calculator, specifically:
    - Pearsall et al. (2021) was reviewed to check the marine survival project conclusions about nearshore development impacts on Puget Sound salmon. Logic was determined to be sound.
    - Duffy et al. (2010) is accurately reflected with respect to the use of nearshore areas as feeding and refuge areas for Puget Sound salmon
    - Lee and Levings (2007) is accurately reflected in that solar irradiation affects survival of surf smelt in the nearshore zone, necessitating riparian shade to buffer overheating
    - McElhany et al. (2000) is accurately reflected in understanding how salmonid population viability is measured in practice and how impacts early in life can impact overall production of the species/population

    - Ono et al. (2010) indeed shows that overwater structures are not passed by migrating juvenile salmonids and that mitigations such as artificial light beneath the structures are ineffective to encourage passage
    - Strange et al. (2002) focused on salt marshes and the restoration of ecological services, which lagged behind the physical effects of recreating habitat according to equivalency analysis

- This reviewer's expertise is specifically in the realm of animal movement and the use of tagging and tracking tools, and it was apparent that there was less literature included using such tools. Some work was cited and there clearly has been efforts to use tracking within Puget Sound. Several works by Moore and Berejikian were lacking that could have provided additional detail about the movements of fish through Puget Sound.

  b) Are there ways to strengthen the functional relationships the Nearshore Calculator is based on?

- A key way to strengthen the functional relationships would be to have a more complete understanding of what habitat is presently available. The amount of shoreline development is stated but I did not see an estimate of the amount of eelgrass habitat or amount of herring spawning beach area. I did find an estimate of the eelgrass coverage in Puget Sound in Thom et al. (2008 Restoration Ecology) so these numbers are available and could be better used to strengthen the functional relationship between habitat and function. On P14 it is stated that no habitats are so limiting that some could not be lost, but this is based on no data and no reference is provided to support such a statement, and is precarious if it is not true. Perhaps it was beyond the scope of the documents to provide the distribution of different habitats, but it seems like considering which habitats are presently available, their abundance, and distribution, would be quite critical to understanding the functional relationships at play.
- Improved understanding of the link between habitat and predation risk would be valuable. Figure 3-7 describes pinniped use as ⅙ of the impact of LSZ development, which seems like an underestimate. Again, the synergy between moving out of refuge and tipping the balance towards ambush hunting by predators using shade is hard to correctly allocate points to, but it seems to me that the role of overwater structures as predator refuge might be underdeveloped here. Overall, habitat often buffers the interplay between predators and their prey in a way that requires additional consideration.
- Stronger understanding of inter-relatedness of habitat mosaic within the nearshore area would be valuable to create more robust adjustment factors. GIS layers should provide effective means of identifying the environmental context that a site sits within, and a continuum of habitat value could be created to directly estimate how activities at a specific site will affect overall functioning of the area.
- A key functional relationship implicit in the Calculator is the relationship between people and the Puget Sound region. Shorelines do not need erosion protection, as they need to erode according to natural processes to yield sediment supply to the nearshore zone. Riparian zones do not need to be modified; they need to cycle through natural succession. It is only because people are building infrastructure, especially houses presumably, close to the sound that armouring and shoreline modification is necessary, because erosion

would impact the property. So while the calculator deals with the ultimate aspects of nearshore modification, it leaves out the proximate causes that may be important to consider farther landward of the riparian zone. New construction or renovation of buildings on shore are highly likely to affect shore-ward processes and consideration of on-shore construction may be added to the calculator to encourage building farther from shore so that erosion protection is less necessary.

- Using published descriptions from tagging and tracking studies to support assertions about the use of nearshore by Endangered species (especially steelhead, which are the focus of Moore and Berejikian's work) would be quite helpful in strengthening functional relationships within the Calculator.

c) Include in your findings a description of strengths and weaknesses.

- Strengths
    - The Nearshore Calculator is comprehensive in its consideration of potential impacts and the details relevant to specific projects, allowing for specific measurements and more accurate estimates of debits and credits from projects
    - The Nearshore Calculator is accessible to those with expertise and access to tools, and the availability of online data sources to support implementation is made clear to users in the User Guide
    - There is a strong evidence base accessed to develop the metrics in the Calculator and it appears that the rationale is strong, and consultations have been both meaningful and fruitful based on reviewing correspondences in appendices, yielding confidence in the approach used to generate the Calculator
    - The Calculator builds on established and tested tools developed by NOAA such as Habitat Equivalency Analysis (despite some drawbacks mentioned below, this is still a strength)
    - Coverage of the tool extends to the riparian zone and demonstrates consideration of both direct and indirect effects of development using a holistic approach
    - The inclusion of adjustment factors makes the calculator adaptable to new knowledge and agile to specific contexts, a great asset to the calculator overall
    - The sheet itself is accessible and the user guide is quite helpful
- Weaknesses
    - Weakness 1) The Nearshore Calculator focuses on maintaining ecological status rather than improving the status of an area that is explicitly described as already in a degraded state. Given that species at risk, specifically Chinook salmon, continue to decline, the effort to maintain status quo with respect to habitat is likely insufficient as an action. It is acknowledged that this principle is predicated on the standard of HEA, which is built on the assumption that habitat is transposable 1:1 and that this weakness may not specifically be attributable to the Calculator itself and rather to concepts beyond the scope of the review, as discussed in the Desvouges et al. critique. It seems unlikely that the NHVM and Calculator can avoid leakage/slippage that will ultimately perpetuate the decline of the species at risk. Moilanen et al. (2009) suggested that very high offset ratios may be necessary to maintain good ecological status.

- Weakness 2) The Nearshore Calculator does not consider the spatial configuration of habitat and treats habitat as a static value that is not influenced by proximate features. Disruption of contiguous pristine habitat may be more adverse than disturbance of a segment of disturbed habitat. A greater focus could be placed on the siting of the impacts in a broader context and whether spatial configuration of the actions is likely to have an above or below average impact on ecological status.
- Weakness 3) The Calculator does not consider interactive effects that can create outsized impacts of action on salmonids migrating through impacted areas. Predation is discussed in brief, but increased migration challenges can be expected to interact with climate factors to create progressively more challenging migrations for salmonids through impacted areas. Docks and wharves that create hiding places for piscivorous animals will increase additive mortality (probably) because it provides a foraging advantage, this is probably changing with climate change and faunal changes in assemblage that could be anticipated if new predatory fish move in. These are challenging to quantify but could be an inflation or adjustment factor to account for the idea that there is more to habitat than its physical qualities but that there are multiplicative effects when habitat is lost.
- Weakness 4) The Calculator does not accurately capture the urgency of migration for juvenile salmonids through the nearshore zone. Increasing time in the coastal zone enhances mortality risk by prolonged exposure to pathogen transmission such as lice and *R. salmonarium* (Duffy et al. 2006 Dis Aquat Org), predators such as seals, and impacts of competitors such as pink salmon that have been documented to impact Chinook survival via putative forage competition early in the migration (Ruggerone and Nielsen 2004 Rev Fish Biol Fish). Delays to migration caused by structures are not necessarily presented to be quite as impactful as they may be, probably in part because the impact is hard to quantify and place a number on, but the diverse ways in which delays actually affect the fish and their probability of survival could be better reflected. Mortality of migrating smolts is neither explicitly quantified nor mentioned in the documents, meaning the understanding of how habitat loss contributes to demographic outcomes is not well developed to underlie the Calculator's functional relationships.
- Weakness 5) The Calculator focuses on impacts on juvenile salmonids but does not discuss returning adults and their use of the nearshore area and their needs for connectivity and migratory corridors to complete the life history. Page 133 of the Endangered Species Act Biological Opinion document states that the nearshore is "crucial" for subadult life stages of ESA listed salmon. For steelhead that are iteroparous, additional impacts will be incurred for kelts that are exiting rivers and migrating again through the nearshore zone to recondition at sea. The Pearsall summary of the Salish Sea Survival Project focuses on juvenile migrations and the factors putatively impacting marine survival, and it is clear that this is important to the Calculator. But it is not clear why adult migrations are completely omitted from consideration. Page 162 of the Endangered Species Act Biological Opinion document states that adult chinook and steelhead do not exclusively rely on the nearshore zone for migration and that overwater structures

are not considered to be a significant impediment, but no reference was provided, and I could not find any data to support this claim. I find it unlikely that nearshore development does not affect adult migrations or kelt migrations for steelhead given that fisheries I am familiar with for adult salmon in coastal water typically operate along shore.

- Weakness 6) It is implied that the location where impacts occur are independent from oceanographic or geological features such that impacted areas will be randomly distributed along a shoreline area. It is more likely that developments occur at specific locations with favourable geological or oceanographic characteristics, meaning that there may be disproportionate loss of certain habitats, creating homogenisation and loss of critical areas. This is partly addressed by adjustment factors (listed as a strength), but adjustment factors are limited in scope. It is stated on P14 that no habitats are so limiting in the area that losses cannot be offset, but this does not seem to be supported by any evidence regarding the amount of habitat that exists for each type nor the amount that is needed to "saturate" the population with ecosystem services such as food and shelter provisioning.
- Weakness 7) Out of kind mitigation is mentioned a few times but is generally unclear what would be eligible. There are a few examples provided and a general framework about equivalent services, but it seems that out-of-kind mitigation would necessarily have to be quite common and that clearer accounting for acceptable out of kind may be needed. As long as habitats share at least one service they can be compensated with some adjustment factor, according to P13 but is that reasonable? It does not make strong ecological sense to replace eelgrass with riparian vegetation I would not think.
- Weakness 8) Insufficient consideration is given to the mechanisms underlying variation in activities. Page 133 of the Endangered Species Act Biological Opinion document states that 48% of residential parcels are armoured; consideration of why some areas are armoured and others are not would help to adjust the calculator appropriately. Is setback distance of the onshore buildings a predictor of adjacent armouring? If so, this could be a key factor considered in the Calculator to incentivise building farther back, which would have cascading benefits.

d) For weaknesses, please outline possible solutions considering the stated goals and the data availability, and if possible, provide references.

- Revisiting whether Habitat Equivalency Analysis is the best tool for all conservation applications would be warranted. It is not clear that HEA was developed to be especially relevant to species at risk and its applications in the literature given that these contexts are more at risk of uncertainty. I could not find any literature supporting that HEA actually is demonstrated to ensure the persistence of critical ecosystem services or, crucially, to support the needs of species at risk. Strange et al. (2002) refers to the time lag of recovering ecosystem services from a physicochemical angle, but does not address services in terms of dependent species usage of the habitat. Adapting HEA with the NHVM bridges some of the gaps but still has limitations that seem to be quite limiting

when considering the likelihood that equivalency would allow persistence of species at risk.

- It should be a priority to investigate the migration of adult salmonids through the nearshore area to more accurately determine the impact of nearshore development on the full life cycle of the salmon. Adult salmon are not feeding as the juveniles are but may avoid over water structures, putting them at higher risk of exposure to predators or other impacts in the nearshore zone. In this way, structures and activities in the nearshore zones may need to be double counted for their impacts if they affect both juvenile and adult migrations or single counted if they only affect one.
- Better consideration of the spatial context in which habitat exists would be beneficial, such as what % of an eelgrass meadow is being removed. This would further benefit from an estimate of habitat types that presently (and even historically) existed within the Sound to more accurately depict the scale of the challenges and opportunities provided by the Calculator to set things in the right direction.
- It should be considered that additive accounting for additional impacts may be insufficient to accurately capture the impacts of shoreline activities on outcomes for species at risk. It is likely that a multiplicative factor could be more appropriate such that new interventions require >1.0 compensation to correct for injurious impacts on species at risk.

2) Scientifically sound process:

a) Does the Nearshore Calculator systematically and appropriately incorporate and interpret the highest priority and best available scientific information given the stated goals and objectives?

- In section 3.4.2.1.1, an impressive overview of literature and observations on the impact of structures on the migration of salmon through nearshore zones is provided. However, the analysis or interpretation falls short of acknowledging the demographic impacts of the knowledge being presented. The summary acknowledges delays and other behavioural alterations as well as increased predation risk, but does not provide any estimate of how structures affect key demographic parameters that influence conservation targets. It is likely that a consequence of these impacts is increased mortality, but this is neither acknowledged nor is any attempt to estimate the magnitude of effect presented. This suggests missing knowledge about the direct impacts of the interventions on the salmon, which hinders the ability to prescribe mitigations that will have a meaningful impact on the conservation of salmon and perhaps should default to a more precautionary approach.
- Key assumptions of the model are that:
    - Impacts of development shoreward from the riparian zone are negligible, which is questionable (it seems likely that impacts of development on shore will have impacts that should be considered)
    - Juvenile salmonids are the primary life stage at which activities in the nearshore zone are impactful on salmon, which is not thoroughly supported, only stated on Page 162 of the Endangered Species Act Biological Opinion document that it is not a concern, without any supporting evidence or data
    - Juvenile salmonids (especially Chinook) use different areas of the nearshore zone differently, which is well supported by work by Duffy and others

- Different habitats have different value for debit and credit (well supported)
- Activities in the nearshore zone affect juvenile salmon migration:
  - timing (not demonstrated)
  - Speed (well demonstrated)
  - Survival (not demonstrated)
- Offsets effectively nullify negative impacts of nearshore impacts, which is not well supported in the documents. The following statement: "As long as similar habitats share at least one function considered in the integrated measure of ecological service, out of kind habitat service values can be determined." Is not supported with data or reference and seems unlikely to be accurate.
- No habitat type is so rare that it cannot be offset with equivalency factors (not well supported; Thom et al. 2018 Restoration Ecology indicate that eelgrass restoration is a high priority, suggesting its loss is not trivial)

b) Indicate if and what relevant information is missing, provide references.

- There is a strong reliance upon the use of visual and capture surveys for understanding the impacts of structures on movements of species at risk. Only a few studies are incorporated that use electronic tagging and tracking tools for monitoring migration and testing hypotheses or setting values to impacts described. Regrettably few studies are available, but Moore and Berejikian (2022 Ecosphere) provide an indication that this approach is very actionable, albeit they worked on steelhead, which have larger smolts. But smaller tags are available, developed in the Pacific northwest PNNL for chinook salmon smolts even.
- Delays can be associated with development of disease as fish that linger can develop infections with pathogens from horizontal transmission or that are coastally associated such as lice (Duffy et al. 2006). This is an important relationship between salmon and habitat.
- Information about the impact of structures on adult migration is systematically missing, but seems to be related to a lack of research on this topic in general, meaning that it cannot be considered or referred to. Nevertheless, the lack of consideration given to adults (and steelhead kelts) remains a key limitation and a more precautionary approach would be warranted to accounting for impacts on adults.
- Although consideration of floating and elevated structures is meticulously developed, the impact of piles or poles to elevate structures, and their effect on water current and predator refuge, did not seem to be considered. A comparison between floating and elevated structures may therefore be warranted, although I could not find detailed references to support whether structures with pilings were more challenging to navigate for migrating fishes. In Figure 4-3, the pilings seemed like they would create a challenge to migrating fish compared to a floating structure, as well as predator refuge that would probably create more challenging migration routes.

c) Indicate if interpretations need to be refined, and if possible, provide references.

- Better knowledge of where, when, and how juvenile and adult salmon and steelhead migrate through the nearshore zone seems needed. Most of the focus seems to be on

juvenile Chinook salmon due to a lack of information about other species and life stages, which is likely to underestimate, and not overestimate, the impacts of development in the nearshore. Steelhead seems to be much less a focus overall, although much tracking work on their migrations through Puget Sound is available but not used in the report.

- The importance of migratory delays and predation caused by overwater structures seems underestimated due to a lack of data. It should be a priority to develop a stronger understanding of the migration patterns of these species in the nearshore, which would support more robust relationships within the Calculator.
- There seems to be very little consideration about eelgrass and how limiting it is. Perhaps there is debate on this, but a few searches indicated that a lot of work has been done by Thom and others on Puget Sound eelgrass and it seems quite affected by development. Better consideration of the work on eelgrass could be useful to harmonise its importance in other literature with how it appears to be represented in the Calculator.

3) Useful/realistic output:

a) Does the Nearshore Calculator generate reasonable and well-supported quantifications of the impacts (positive, negative, neutral) to nearshore habitats and salmon?

- Habitat Equivalency Analysis may provide well-supported quantifications on impacts to nearshore habitats, but it is not clear that this extends to salmon. Some suggested mitigations such as offsetting loss of eelgrass with riparian vegetation is quite unlikely to effectively replace the services required by salmon. It is critically important to understand whether the objective is to simply replace lost habitat with an equivalent or whether it is to contribute meaningfully to the conservation of Endangered salmons. Lack of published literature demonstrating that HEA-type mitigations are successful in the context of species recovery or persistence suggests that it is not well supported as a tool for supporting the survival of species at risk and a more conservative baseline as a fundamental to the NHVM might be warranted.
- The quantifications of impacts are reasonable with respect to nearshore habitats. The data supporting the delineation of the nearshore zones and the evaluation of the functioning of these habitats is sensible and likely provides an accurate assessment of habitat function. Quantifications of impacts on salmon are reasonable but limited to juveniles with no consideration of adults; given that this question specifically refers to impacts to “salmon” and not “juvenile salmon” the omission of impacts on adult salmon from the document is noted again. It is implied that the impacts on adult salmon are null, which is not reasonable without justification. If the effects are not null, it suggests that credits/debits and adjustment factors may be underestimated.

b) If warranted, include in your findings a description of where the Nearshore Calculator likely over- or under-estimates impacts or benefits to salmon and their habitat.

- It is likely that the calculator under-emphasises how adult salmon that migrate through the nearshore zone are affected by habitat modification and predation by seals.
- An adjustment factor of 2x for new structures is positive and may have taken a lot of consultation to determine, but in an area that is so highly developed the loss of pristine habitat is probably a very severe loss, and a higher adjustment factor could be considered

to account for the fact that unaltered shoreline is quite limited, and that loss of additional natural shoreline is severe.

- Use of a 5 mile and 1 mile radius around estuaries seems somewhat arbitrary and should perhaps be more of a continuum, which would not be too challenging to implement in practice. P14 of Ehringer et al. (2015) points out that several estimates have been used and 5 miles is fairly conservative, which is good, but perhaps higher adjustment factors further in would be warranted. It is not clear that an adjustment factor of 2x is the maximum.
- It seemed that the focus on beach nourishment may have been a bit high, although sediment dynamics are extremely important in coastal zones, it seemed there was a large focus on beach nourishment and not as much evidence to support it as a mitigation compared to other actions. Beach nourishment therefore seems to overestimate benefits. Review of the Lambert and Chamberlain document suggests that this may be altered once that document is published given the inconsistencies of findings by the review.
- Loss of eelgrass seemed to be undervalued, especially when considering the suggestion that eelgrass destruction could be replaced by riparian vegetation that takes many years to mature and provide sufficient shade. Eelgrass is sensitive and extremely valuable for multiple functions and should be re-evaluated for an appropriate adjustment factor, especially given that it is hard to replant and restore when lost. Literature on eelgrass in Puget Sound indicates that it is quite limiting, challenging to restore, and its loss should be taken into higher consideration, perhaps via an adjustment factor.
- It is somewhat likely that the calculator under-estimates the impact of migration delays and behavioural alterations on survival and fitness of salmon as a result of structures being added or removed from overhead. Throughout the document, there is a lack of explicit consideration given to the ultimate impacts of activities in the nearshore zone upon salmon. Proximate impacts are well described but without a stronger empirical consideration of how impacts translate to fitness indicators, there will be uncertainty. It is not beyond the scope of the calculator to consider ultimate impacts (i.e., death) although it would be challenging without a suitable control area to evaluate migration through unimpacted areas, which is probably why it is not addressed. Still, efforts to address this as an uncertainty and to acknowledge that migration delays and behavioural alterations will increase mortality, and may be additive mortality that affects the eventual abundance of returning adults, spawners, and egg production, should be included.

c) If warranted, outline possible solutions for better supported quantifications and if possible, provide references.

- Consideration of alternatives to Habitat Equivalency Analysis or further adjustments to the HEA framework would be more likely to produce meaningful conservation results given that it was developed more for habitat rather than conservation of species at risk.
- The Calculator is complimented for incorporating and synthesising a large body of evidence, and it is recognised that shortcomings are not likely reflective of failures to consider relationships between fish and habitat.
- New research is needed to understand movements of fish though the nearshore area and their use of key areas and corridors, including the importance of unobstructed corridors. Certainly, additional research to fill the key gaps would be an important step forward. I

was not able to find substantially lacking primary research to support solutions to the gaps identified, which is probably why the gaps exist.

- Quantifying key predictors of shoreline armouring would help to make recommendations to proponents or to consider activities in the shore zone (upshore of the riparian zone) about offset distances.
- More expertise on eelgrass and whether it is accurately represented within the Calculator when lost due to activities in the nearshore zone would be valuable. It does not seem likely that replacement via offsetting is sufficient to restore its services.

Conclusions

The Nearshore Calculator is an impressive tool in its scope and breadth for quantifying debits and credits for nearshore zone activities in Puget Sound. The Calculator is complimented for considering a large evidence base on the migration of salmon through the nearshore zone and for extending its scope from the riparian out to the deeper shore zone when contemplating how activities in Puget Sound will impact species at risk. This is despite a lack of data available about the habitat used by juvenile and adult salmon within the nearshore zone, apparently largely supported by netting surveys and visual observations. It was not stated anywhere in the calculator that impacts were expected to be more prominent or important upon juvenile salmon than on adults, meaning that no consideration is given to the fact that adults migrate back through Puget Sound nearshore areas, and steelhead kelts will exit rivers to return to sea through the nearshore, and can be made more vulnerable to predation or migration delays by activities in the nearshore. While the Calculator is developed based on an impressive evidence base, it is clear that some important links to fitness are missing in the literature that limits the ability of the authors to make effective estimates of how fish are ultimately impacted by actions. Much of the evidence base affirms that shoreline interventions such as dredging, armouring, and in/over water structures can cause migration delays, alter behaviour, and affect feeding but there is a missing link in considering how important these impacts are on the demographics of the salmon populations, i.e. to what extent is mortality increased by migration delays and how much additive mortality might be attributed to loss of critical habitat for foraging. Without an effective estimate of how much immediate and delayed mortality could be linked to nearshore impacts, an effective calculator of debits and credits will not be possible regardless of how throughout the literature review is.

Recommendations

Habitat Equivalency Analysis, although validated as a legal instrument, appears to not be well tested in the context of conserving species at risk. HEA seems to have been designed with the objective to ensure no net loss of habitat, not to sustain ecosystem services and the persistence of species at risk. No evidence is provided that habitat equivalency is sufficient to support persistence of the salmonids at risk and is a critical uncertainty that should be considered.

There appears to be a template for tracking juvenile salmonids through the nearshore zone based on steelhead research in Puget Sound by Moore and Berejikian, and for Chinook by Celedonia et al. (2008). Tracking fish through the nearshore will help to affirm some of the results and provide a better quantification of usage of the different areas during migration. Tagging experiments would support experimental approaches using temporary structures in a

randomised control treatment design to quantify the impacts of migrating past one or more structures on migration timing, speed, and survival. Putting numbers on impacts would be valuable to calibrate the Calculator with empirical estimates of ultimate impacts of structures. Additional research is needed to estimate the migration routes of adults through Puget Sound and the nearshore zone.

Considering an additional tab in the Calculator that details impacts on the shore zone, especially building distances to the shore, could help to better quantify impacts of activities proactively given that new constructions, expansions, or renovations on shore may lead to the need for erosion protection or other activities in the riparian and upper shore zone.

Adjustment factors are an important aspect of the Calculator allowing transparent and necessary modification to scoring to account for heterogeneity of the habitat mosaic. Adjustment factors appeared to be conservative and could be more systematic using open GIS tools to map critical habitats. For example, habitat maps could be established, and kriging or smoothing could be used to identify hotspots and transition zones with more continuous, spatially explicit adjustment factors depending on proximity to critical habitat. Higher adjustments for loss of eelgrass could be considered, as well as other habitats if a more thorough GIS-based analysis of habitat types in the Sound were conducted to inform the Calculator.

Uncertainty is given strong consideration in the Calculator but nearly all assessments of uncertainty suggest that it is likely that effects are underestimated by the tool, meaning that adjustments may be needed to correct for uncertainty. The finding that so many pieces of uncertainty pointed to underestimation of effects was surprising and felt it could be addressed to balance the uncertainty a bit more evenly.

Appendix 1: Bibliography

1. Main documents
    a. Ehinger et al. 2023. Nearshore Calculator Scientific rationale.
    b. Nearshore calculator Excel Spreadsheet
    c. Nearshore Habitat Values Model Excel Spreadsheet
2. Background documents
    a. User guide
    b. Cereghino et al. 2023. Estimation of Typical High Intertidal Beach-Face Slope in Puget Sound. NOAA Process Report.
    c. Ehinger et al. 2015. Use of The Puget Sound Nearshore Habitat Values Model with Habitat Equivalency Analysis for Characterizing Impacts and Avoidance Measures for Projects that Adversely Affect Critical Habitat of ESA-Listed Chinook and Chum Salmon. NMFS Internal Document.
    d. Lambert and Chamberlin. 2023. Beach nourishment in Puget Sound: status, use, and habitat impacts.
    e. Salish Sea Nearshore Programmatic Biological Opinion
3. Additional documents
    a. CIE Example overwater structure replacement PowerPoint Presentation

Appendix 2: Performance Work Statement

Performance Work Statement (PWS)
National Oceanic and Atmospheric Administration (NOAA)
National Marine Fisheries Service (NMFS)
Center for Independent Experts (CIE) Program
External Independent Peer Review
Under Contract #1305M219DNFFK0025

CIE Desk Review of the Puget Sound Nearshore Conservation Calculator and the integral Puget Sound Nearshore Habitat Values Model

Background

The National Marine Fisheries Service (NMFS) is mandated by the Magnuson-Stevens Fishery Conservation and Management Act, Endangered Species Act, and Marine Mammal Protection Act to conserve, protect, and manage our nation's marine living resources based upon the best scientific information available (BSIA). NMFS science products, including scientific advice, are often controversial and may require timely scientific peer reviews that are strictly independent of all outside influences. A formal external process for independent expert reviews of the agency's scientific products and programs ensures their credibility. Therefore, external scientific peer reviews have been and continue to be essential to strengthening scientific quality assurance for fishery conservation and management actions.

Scientific peer review is defined as the organized review process where one or more qualified experts review scientific information to ensure quality and credibility. These expert(s) must conduct their peer review impartially, objectively, and without conflicts of interest. Each reviewer must also be independent from the development of the science, without influence from any position that the agency or constituent groups may have. Furthermore, the Office of Management and Budget (OMB), authorized by the Information Quality Act, requires all federal agencies to conduct peer reviews of highly influential and controversial science before dissemination, and that peer reviewers must be deemed qualified based on the OMB Peer Review Bulletin standards[1].

Scope

NMFS is requesting peer review of the Puget Sound Nearshore Conservation Calculator (Nearshore Calculator) and the integral Puget Sound Nearshore Habitat Values Model to strengthen the quality and credibility of the agency's science, and improve stakeholder's trust that the agency is basing policy decisions on the best scientific information available.

[1] https://www.whitehouse.gov/wp-content/uploads/legacy_drupal_files/omb/memoranda/2005/m05-03.pdf

NMFS designated critical habitat for Puget Sound (PS) salmonids in 2005 (70 FR 52629, Sept. 2, 2005). NMFS's designation of salmonid critical habitat describes which physical and biological features (PBFs) support the specific conservation roles of habitat. For estuarine and nearshore marine areas, essential PBFs of habitat for PS Chinook and Hood Canal Summer Run (HCSR) chum salmon include (1) unobstructed rearing and migration corridors; (2) forage including aquatic invertebrates and fish, supporting growth and maturation; (3) natural cover such as submerged aquatic vegetation and large wood;[2] and (4) water quality supporting juvenile and adult physiological transitions. NMFS used these PBFs as a framework for developing the Puget Nearshore Calculator, consistent with how NMFS evaluates effects on critical habitat under ESA section 7.

NMFS West Coast Region (WCR) developed the Nearshore Calculator to assist in analyzing the impact of proposed local development action in nearshore marine habitats within Puget Sound, Washington. The Nearshore Calculator is based on Habitat Equivalency Analysis (HEA) (Described in section 3 of Ehinger et al. 2023). The Nearshore Calculator is an easy-to-use interface for the Nearshore Habitat Values Model (NHVM). NMFS WCR designed the NHVM to consistently determine habitat service values to be used as input parameters in HEA.

For use as an analysis tool for ESA consultations, the Nearshore Calculator is based on evaluation of the PBFs and the conservation roles of those features - survival, growth, and maturation – and likely effects of proposed actions on population level viability (abundance, productivity, spatial structure, and diversity, or "VSP"[3]) for salmonids. The Nearshore Calculator quantifies changes to PBFs of listed salmonid habitat and considers how these changes likely affect salmonid growth, development, and VSP and as a corollary, the relative conservation value of an area of habitat. The formal structure and science-based quantitative assessment results in a more predictable quantification of the impacts of actions during an ESA consultation, which is valuable because it improves consistency, efficiency, and transparency. Finally, the Nearshore Calculator is amenable to revision based on new science.

NMFS requests that the CIE reviewers conduct a peer review of the scientific information and framework of the Nearshore Calculator based on the Terms of Reference (TORs) referenced below.

The specified format and contents of the individual peer review reports are found in Annex 1. The Terms of Reference (TORs) of the peer review are listed in Annex 2.

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[2] The description of the estuarine PBFs further outlines "These features are essential to conservation because without them juveniles cannot reach the ocean in a timely manner and use the variety of habitats that allow them to avoid predators, compete successfully, and complete the behavioral and physiological changes needed for life in the ocean." ." https://www.federalregister.gov/d/05-16391

[3] The process NMFS typically uses to evaluate impacts on listed salmonids uses the viable salmonid population (VSP) concept (McElhany et al. 2000). McElhany et al. (2000) identified four parameters to evaluate the viability of a population: abundance, population growth rate, population spatial structure, and diversity. When analyzing the effects of actions on listed species as part of an ESA section 7 consultation, NMFS usually analyzes the effects on each of these parameters.

Requirements
NMFS requests five (5) reviewers to conduct an impartial and independent peer review in accordance with the performance work statement (PWS) and the TORs below. Each reviewer should have working knowledge and recent experience in a minimum of three of the following areas:

(1) Salmon ecology;
(2) Marine nearshore ecology and/or conservation biology;
(3) Development of models preferably in the context of making decisions to avoid, minimize, or mitigate potential impacts;
(4) Science of valuing habitat for fishes based on ecological functions and services;
(5) Quantifying effects of physical changes (like the installation of shoreline armoring) on habitat conditions and functions;
(6) Quantifying effects of changes in habitat condition (structure & functions including vegetation, prey productions, water quality) on fish (preferably salmon) growth and survival.

In addition, knowledge and experience with Habitat Equivalency Analysis is helpful, though not required. Each CIE reviewer's duties shall not exceed a maximum of 10 days to complete all work tasks of the peer review described herein.

Tasks for Reviewers
Each CIE reviewer shall complete the following tasks in accordance with the PWS and Schedule of Milestones and Deliverables herein.

1. Pre-review Background Documents: Two weeks before the peer review, the NMFS Project Contact will send by electronic mail or make available at an FTP site to the CIE reviewer all necessary background information and reports for the peer review. In the case where the documents need to be mailed, the NMFS Project Contact will consult with the CIE on where to send documents. The CIE reviewer shall read all documents in preparation for the peer review:

Main Documents:

- Nearshore Calculator Scientific rationale (central document providing background and information for quantifications developed for Nearshore Calculator) 145 pages + appendices (Ehinger et al. 2023)
- Nearshore Calculator – Excel Spreadsheet, available on NOAAs web page.
- Annotated and updated Excel Nearshore Habitat Values Model.

Background Documents:

- User Guide (provides instruction on how to populate fields and get impact/benefit results from calculator) – available on NOAAs web page at: https://www.fisheries.noaa.gov/resource/tool-app/puget-sound-nearshore-conservation-calculator, 60 pages.
- Cereghino et al. 2023 – (describes GIS layers developed to identify Highest Astronomical Tide (HAT) lines in Puget Sound) 45 pages.
- Historic document Ehinger et al. 2015 on previous model version.
- Lambert and Chamberlin. 2023. Beach nourishment in Puget Sound: status, use, and habitat impacts - in final review by authors.
- Salish Sea Nearshore Programmatic (SSNP) Biological Opinion

2. Webinar: Approximately two weeks after the CIE reviewers receive the pre-review documents, they will participate in a webinar with the NMFS Project Contact and Nearshore Calculator team members to address any clarifications that the reviewers may need regarding the TORs or the review process. The NMFS Project Contact will provide the information for the arrangements for this webinar.

3. Desk Review: Each CIE reviewer shall conduct the independent peer review in accordance with the PWS and TORs, and shall not serve in any other role unless specified herein. Modifications to the PWS and TORs cannot be made during the peer review, and any PWS or TORs modifications prior to the peer review shall be approved by the Contracting Officer's Representative (COR) and the CIE contractor.

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

Place of Performance
Each CIE reviewer shall conduct an independent peer review as a desk review, therefore no travel is required.

Period of Performance
The period of performance shall be from the time of award through September 2023. The CIE reviewers' duties shall not exceed 10 days to complete all required tasks.

Schedule of Milestones and Deliverables
The contractor shall complete the tasks and deliverables in accordance with the following schedule.

Within two weeks of award	Contractor selects and confirms reviewers
No later than two weeks prior to the review	Contractor provides the pre-review documents to the reviewers
September 2023	Each reviewer conducts an independent peer review as a desk review
Within two weeks after review	Reviewers submit draft peer-review reports to the contractor for quality assurance and review
Within three weeks of receiving draft reports	Contractor submits five (5) final independent Peer-Review reports to the Government

Applicable Performance Standards
The acceptance of the contract deliverables shall be based on three performance standards: (1) The reports shall be completed in accordance with the required formatting and content; (2) The reports shall address each TOR as specified; and (3) The reports shall be delivered as specified in the schedule of milestones and deliverables.

Travel
Since this is a desk review travel is neither required nor authorized for this contract.

Restricted or Limited Use of Data
The contractors may be required to sign and adhere to a non-disclosure agreement.

Project Contact:
Kim Kratz
kim.kratz@noaa.gov
NMFS, West Coast Region
1201 NE Lloyd Blvd, Suite 1100, Portland, OR 97232

Annex 1: Peer Review Report Requirements

1. The report must be prefaced with an Executive Summary providing a concise summary of the findings and recommendations, and specifically whether the Nearshore Calculator represents the best available science and if not, what specific improvements you recommend.
2. The main body of the reviewer report shall consist of a Background, Description of the Individual Reviewer's Role in the Review Activities, Summary of Findings for each TOR in which the weaknesses and strengths are described, and Conclusions and Recommendations in accordance with the TORs.
3. The reviewer report shall include the following appendices:
    1. Appendix 1: Bibliography of materials provided for review
    2. Appendix 2: A copy of the CIE Performance Work Statement

Annex 2: Terms of Reference (TOR) for the Peer Review

The reviewers will provide input on the following questions. During your evaluation, please keep in mind that the Nearshore Calculator must use the best available science, Endangered Species Act consultations cannot be delayed until better science becomes available, and the Nearshore Calculator can be modified over time as additional science becomes available.

1) **Analytically sound process:**
    a) Are the underlying relationships that Nearshore Calculator and the NHVM are built upon (e.g. duration of aquatic access, functional pathways, indicators/metrics) sufficient and well-founded for evaluating effects of changes to nearshore habitat conditions on salmonids, given the stated goals and objectives? Is the analytical approach based on a valid list of habitat attributes (physical and biological functions)?
    b) Are there ways to strengthen the functional relationships the Nearshore Calculator is based on?
    c) Include in your findings a description of strengths and weaknesses.
    d) For weaknesses, please outline possible solutions considering the stated goals and the data availability, and if possible, provide references.
2) **Scientifically sound process:**
    a) Does the Nearshore Calculator systematically and appropriately incorporate and interpret the highest priority and best available scientific information given the stated goals and objectives?
    b) Indicate if and what relevant information is missing, provide references.
    c) Indicate if interpretations need to be refined, and if possible, provide references.
3) **Useful/realistic output:**
    a) Does the Nearshore Calculator generate reasonable and well-supported quantifications of the impacts (positive, negative, neutral) to nearshore habitats and salmon?
    b) If warranted, include in your findings a description of where the Nearshore Calculator likely over- or under-estimates impacts or benefits to salmon and their habitat.
    c) If warranted, outline possible solutions for better supported quantifications and if possible, provide references.

Objectives for the Nearshore Calculator

In summary, the Nearshore Calculator is designed to be:

- Rapid and Efficient – quantify habitat services using data typically provided as part of ESA-consultation packages.
- Accessible – invite use by biological consultants, agency personnel, and applicants.
- Transparent – allow users to review every element of an assessment.
- Consistent – produce repeatable results through the use of objective indicators and criteria. Expert opinion is thoroughly developed and reviewed and then frontloaded into the Nearshore Calculator rather than applied by individual biologists.
- ESA-based – references PBFs of critical habitat and effects on the survival, abundance, and productivity of listed salmonids.
- Duration-sensitive – consider the duration of impacts and benefits.
- Scaled to level of effects – evaluate the small difference in common project types, for example, the changes in shading caused by the size of overwater structures and the use of grating.
- Adaptable – allow for the incorporation of new science or best available information.