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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

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Disclaimer

This is a living document. The best available science has been used to develop this document and it has undergone extensive internal review consistent with Data Quality Act provisions of utility, integrity and objectivity. We expect to periodically update this document as we receive input and new information to improve the sensitivity, objectivity, and usability of the model.

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Chapter 1: Overview of the Use of Habitat Equivalency Analysis to Avoid Adverse Critical Habitat Impacts to ESA-listed Salmon

Jeffrey P. Fisher, Stephanie I. Ehinger

1.0 Introduction

Under Section 7 of the Endangered Species Act (ESA, 16 U.S.C. 1531-1544, 87 Stat. 884, amended as P.L. 93-205), the National Marine Fisheries Service (NMFS) is mandated to review actions conducted, permitted or funded by Federal agencies that occur in areas that support ESA-listed species and/or their designated critical habitat (CH). A principal objective of these 'consultations' is to ensure that otherwise lawful actions that incidentally and adversely affect ESA-listed species' habitat are minimized and offset to the maximum extent practicable. Thus, in consultation NMFS seeks to assist the Federal action agency by identifying means for avoiding and minimizing impacts. Further, NMFS examines how project may affect recovery objectives identified in species recovery plans over the long term (USFWS & NMFS, 1998). Although best management practices are effective at addressing many potential construction-related impacts to ESA-listed species, often some long-term effects to habitat forming processes remain. These residual impacts often result after construction, as the new infrastructure becomes a component of the aquatic environment to which the species' must respond. The changes to habitat forming processes resulting from new and essentially permanent infrastructure (e.g., docks/piers/bulkheads) may compromise the ability of the modified habitat to enable the listed species' to complete their life history, and to meet recovery trajectories.

The NMFS contends that habitat degradation can be offset by better mitigating for the residual functional deficits to habitat that remain after implementing avoidance and minimization measures during the Section 7 ESA consultation process. To support the analysis of these residual impacts, the use of a consistent 'habitat currency' transparently applied to characterize adverse and/or beneficial impacts to salmonid habitat from federally funded and/or permitted actions is needed. This document outlines a tool for NMFS employees, action agencies, and applicants to quantify how much habitat lift is needed to offset adverse impacts to Puget Sound (PS) Chinook salmon and Hood Canal (HC) summer chum salmon CH for projects proposed in the PS nearshore.

A common 'habitat currency' to quantify habitat impacts or gains can be calculated using Habitat Equivalency Analysis (HEA) methodology when used with a tool to consistently determine the habitat value of the affected area before and after impact. The NMFS selected HEA as a means to identify section 7 project related habitat losses, gains, and quantify appropriate mitigation because of its long use by NOAA in natural resource damage assessment to scale compensatory restoration (Dunford et al. 2004; NOAA 2006), extensive independent literature on the model (Milon and Dodge 2001; Cacela et al.

2005; Strange et al. 2002), and previous judicial review validating the model's use for addressing habitat impacts (United States of America vs. Melvin A. Fisher et al. 1997) and mitigation needs for addressing past injuries to natural resources. In Washington State, NMFS has also expanded the use of HEA to calculate conservation credits available from fish conservation banks (NMFS 2001, NMFS 2013), from which 'withdrawals' can be made to address mitigation for adverse impacts to ESA species and their designated CH under NMFS recovery mandate.

Essential input parameters for running HEA include the value of the subject habitat, the area of the subject habitat, the time it will take for the habitat to reach full function, and the time the subject habitat will exist in the state evaluated. While the area and durations are relatively easy to determine, the functional value of the altered habitat will differ depending on the role of the subject habitat to support life history elements of the target species utilizing the habitat. However, to use HEA and expect consistent and valid estimates of habitat impacts, the habitat values need to be determined with a consistent and reliable method.

The NMFS developed a Nearshore Habitat Values (NHV) model to allow for consistently assigning habitat values for PS Chinook and HC summer-run chum in nearshore habitats in the PS and HC. The NHV model facilitates using HEA consistently for impact and restoration analyses in the PS and HC nearshore. The application of HEA with the use of appropriate habitat values is intended to be applied when adverse habitat impacts from project implementation are reasonably certain to occur in the long term (e.g., a new pier-ramp-float over herring spawning bed). The development of the model is in keeping with NMFS Habitat Blueprint guiding principle to 'Implement innovative place-based habitat solutions to address coastal and marine resource challenges' (http://www.habitat.noaa.gov/blueprint/faq.html) The NMFS methods outlined in this document provide tools for the quantification of adverse and beneficial habitat impacts to ESA-listed PS Chinook salmon, and HC summer-run chum. They are not intended to capture short-term impacts to species from ephemeral, construction-related effects such as underwater noise or suspended sediment; such effects are typically minimized or avoided completely through the application of best management practices. The HEA applications outlined here enable consulting biologists to quantify the mitigation needs in the PS and HC nearshore region prior to (or after) submitting a project for consultation. The NMFS is developing further tools to consistently determine habitat values in other West Coast Region areas, and an update of this document outlining the habitat values for these types of systems will be forthcoming.

1.1 Achieving No Net Loss of Functional Habitat Value

In its effort to achieve no net loss of habitat function, NMFS is in step with other agencies and local jurisdictions all working on implementing the same goal (Patterson et al., August 2014). The local efforts are reflected in Washington's updated Shoreline Master Program which is based on the goal of no net loss of ecological functions.

During the section 7 consultation process, NMFS works with the Federal action agency and applicants to avoid, minimize, and offset adverse habitat impacts of proposed actions. Options to achieve no net loss include:

1. Avoiding the impact and/or
2. Minimizing impacts and/or
3. Compensating for the impact on-site and/or
4. Compensating for the impact off-site, within an area supporting habitat of equivalent or greater value to the population(s) affected by the project action's impacts.

The NMFS and other resource agencies have applied this mitigation sequence of avoidance, minimization, and mitigation in the past and will continue applying it. What is new is that HEA can assist in reliably quantifying *functional* impacts that remain after avoidance and minimization measures have been implemented to the fullest extent practical. The NMFS will consider a variety of mitigation approaches to offset impacts if the HEA analysis concludes that residual impacts to CH remain from the action. Options include: riparian plantings, in-water structure removal, withdrawals from established fish conservation banks, contributions to *in-lieu* fee programs, withdrawals from Corps and EPA-approved wetland mitigation banks with NMFS-approved fish habitat overlays, and contributions to fully designed projects sponsored by not-for-profit habitat restoration entities. These mitigation options are not necessarily new, and have been (and can still be) used in many cases in the absence of applying the HEA methodology described herein. The purpose of developing the HEA and NHVs methodologies was to address concerns over consistency in the interpretation of the functionality provided by mitigation at a site-specific scale.

2.0 The HEA Methodology

2.1 Concept and Currency

The HEA method assesses both ecological services lost or gained by taking into consideration: (1) the relative values of the subject habitat before and after a project is implemented, (2) the size of the area affected where the damage (or habitat improvement) has occurred, (3) the time it takes for altered habitats to reach fully functioning condition, (4) the duration for which the altered habitat is expected to remain in place (e.g., how long a pier will remain in place, or a restored habitat is expected to exist), and (5) a discounting factor. The HEA estimates the total net loss or gain of ecosystem service to an affected area with these five input parameters. The discounting factor, as in economics, is used to account for the difference between when the loss in ecosystem service occurs and when the restored habitat becomes fully functional (NOAA 1999, Ray 2008).

The functional loss or gain of the ecosystem service(s) assessed with HEA is expressed in a dimensionless unit known as *Discounted Service Acre Years* (DSAYs). NMFS uses DSAYs as the common habitat currency and calculates it using the HEA. The debt is the functional loss in ecosystem services that are essentially withdrawn, or made inaccessible from the impacted habitat. The number of DSAYs lost from the impact indicates how much restoration of the damaged site and/or construction (restoration) of functional habitat would be needed to offset the lost habitat functions.

The underlying concept of using a common currency to express functional habitat loss and gain is known as *ecological equivalency*. Ecological equivalency is a service-to-service approach that assumes that the ecological functions and services for a species or group of species that are gained from habitat at a restored site fully offset the functions and services lost at an impacted site, when discounting and time to full function at the restored site are incorporated into the analysis. Applying HEA requires balancing reductions in habitat quality against gains from restoration actions without losing limiting habitat functions (Cacela et al., 2005). Strange et al. (2002) explain, that the underlying assumption of HEA is that the public will accept a one-to-one trade-off between a unit of lost habitat services and a unit of restoration project services. Thus, there is not necessarily a one-to-one trade-off in terms of specific resources but rather in the services they provide for the species impacted.

NMFS incorporates a standard 3 percent discounting factor when using HEA for quantifying habitat impacts and benefits, expressed in DSAYs. This discounting rate is based on economic theory that contends that the public places a greater value on services obtainable presently versus the enjoyment they could obtain from those same services in the future. For further information on the HEA procedure and DSAYs see NMFS (1999), and Strange et al. (2002).

Chapter 2: Puget Sound Nearshore Habitat Value Determination Model

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2.1 Introduction

This chapter presents the Nearshore Habitat Values (NHV) model for determining functional values of nearshore habitat in Puget Sound (PS) for Endangered Species Act (ESA)-listed PS Chinook and Hood Canal (HC) summer-run chum salmon. Specifically, the NHV model outlined herein is a tool to assist in evaluating the capacity of the PS nearshore environment to support the primary constituent elements (PCEs) of designated critical habitat (CH) for PS Chinook salmon and HC summer-run chum salmon at a site-specific scale. The NHVs discussed in this chapter consider the functions the habitat provides for the PCEs of *forage, cover, water quality and migration*, consistent with the estuarine and marine PCEs recognized for ESA-listed salmon (70 FR 52664, September 2, 2005). The NHVs are used as input parameters in HEA calculations to determine ecological gains and losses associated with projects that trigger section 7 consultations under the ESA. The main goal of using HEA to quantify changes to salmonid CH is to aid in determining what constitutes appropriate mitigation for adverse impacts to CH, as discussed in Chapter 1. In application, a before/after assessment of the subject areas that may be adversely affected by the project is conducted to determine the NHVs and ultimately the amount of habitat improvement or degradation that may result.

During development of this tool, we recognized the NHV model's utility would be maximized if it provided: (1) applicability PS-wide, (2) ease of use for section 7 biologists, action agencies, and permit applicants to apply after attending a training session on its use, (3) a quantitative evaluation of the capacity of the PS nearshore to support the critical habitat PCEs of *forage, cover, water quality, and migration* for PS Chinook and HC summer-run chum salmon, and (4) sufficient sensitivity to quantify habitat impacts from small-scale (e.g., residential dock) to large-scale (e.g., yacht clubs, ferry terminals) nearshore development projects as well as nearshore restoration projects. Based on a long history of consultations previously processed through NMFS, the workgroup considered it essential that the habitat modifications the model considers included:

- Addition/removal of riparian vegetation
- Addition/removal of impervious surface in the PS riparian corridor
- Addition/removal of shoreline armoring
- Addition/removal of nearshore fill including pilings
- Addition/removal of shading from overwater structures (OWS)
- Impacts to sediment quality, transport, and sorting from structures

Prior to developing the NHV model, we reviewed three other regional models for evaluating habitat values, and found that they did not meet NMFS specific needs and criteria. While the HC Nearshore Functional Assessment tool (AECOM, 2013) has similar goals for quantifying habitat impacts from the above listed impacts, it quantifies impacts to the entire ecosystem, including rockfish and birds, not just to PS Chinook and HC summer-run chum salmon PCEs. The Tidal Habitat Model (City of Everett and Pentec 2001) seemed too complex for application to individual projects that NMFS consults on under section 7 and does not allow for evaluating all effects, as listed above, from nearshore development actions relevant to section 7 consultations. Iadanza (2001) documented how NMFS' restoration center, determined habitat values for nine different estuarine habitats in Commencement Bay for, among other species, juvenile Chinook use. For this Commencement Bay project, NMFS' restoration center worked in cooperation with stakeholders as part of the National Recourses Damage Assessment action applied to Comprehensive Environmental Response, Compensation, and Liability Act-driven remediation. In that effort, Iadanza (2001) delineated nine different habitat types in Commencement Bay based on tidal elevation, substrate, and riparian conditions. This catalogue approach, assigning a value to a distinctly described habitat polygon within a discrete area, was acceptable for evaluating riparian conditions PS-wide and was adopted as one component for the NHV model described here. However, this approach did not work for the nearshore habitats and impacts identified above, as PS-wide conditions are too numerous. In brief, the catalogue of different nearshore habitat types would have been too extensive to be workable, and literature to support the differential functions provided for PS Chinook and HC chum among the range of nearshore habitats available was deemed insufficient to scientifically support such a catalogue at this time. Instead, application of the NHV model detailed in this chapter assesses the PCEs present at a project site and derives a habitat value through averaging across the values assigned to PCE functions for PS Chinook and HC chum within nearshore strata delineated by elevation relative to the Mean Lower Low Water (MLLW).

2.2 Methods Overview

PS Chinook salmon and HC summer-run salmon depend on the estuary and nearshore for early rearing (Duffy 2005; Healey 1982 & 1991; Salo 1991, Simenstad et al. 1982). The utility of the nearshore to support critical life history functions of juvenile PS Chinook and HC summer-run salmon varies depending on its elevation and associated characteristics. Thus, the affected area is separated by elevation into four nearshore zones: (1) the Riparian Zone (RZ), (2) the Upper Shore Zone (USZ), (3) the Lower Shore Zone (LSZ), and (4) the Deeper Critical Habitat Zone (DZ). These zones are depicted in a graphical example displayed in Figure 1.

The methods forming the basis of our PS NHV model reflect agency regulations for the designation of critical habitat (50 CFR 424.12(b)) that we must consider "those physical or biological features that are essential to the conservation of a species…including space…; food, water,…; cover or shelter; sites for …rearing of offspring and focus on the principal biological or physical constituent elements…that are essential to the conservation of the species". In particular, the model relies on the PCE "nearshore marine areas" definitions as detailed in 70 FR 52630. As such, the goal of this model is to quantify how alterations of nearshore conditions influence the functionality of the "estuarine areas" and "nearshore marine areas" by altering migration and early marine rearing, water quality, forage, and cover. For example, natural shorelines provide high levels of forage from terrestrial inputs of insects and organic material that supports the detrital benthic forage base (Duffy et al. 2010; Simenstad 2000; Sobocinski et al. 2010). Further, many natural shorelines recruit sediments to the nearshore that support forage fish spawning areas. Natural shorelines also provide shallow water habitat which supports successful migration, whereas bulkheads and overwater structures generally impede successful migration. Finally, natural shorelines usually provide more cover such as overhanging large wood, and in-water beach wrack and large woody materials (LWM) compared to stabilized and altered shorelines.

During Section 7 analysis of a proposed project's effects, each assessment zone's NHVs are evaluated by answering a series of 'before' and 'after' questions that examine functional indicators of the PCEs supported in each assessment zone. The questions are contained in separate Excel™ worksheets for each of the assessment zones (i.e., RZ, USZ, LSZ, and DZ) within a master program file (PS NHV-HEA.xls). We considered the habitat indicators selected for the model's questions to be most relevant to an assessment of the quality of the juvenile Chinook and HC summer-run chum estuarine and marine PCEs, and most sensitive to nearshore project impacts such as bulkheads and overwater structures. These indicators included:

- Riparian Vegetation Composition and Condition (within 50 lateral feet of the HAT)
- Shoreline Condition
- Shallow Water Habitat Availability and Access
- Large Woody Material (greater than 10 cm diameter at breast height)
- Substrate Quality
- Aquatic Vegetation (for USZ and LSZ) or Primary Productivity (for DZ)
- Water Quality

2.2.1. Applicable for all worksheets: Acceptable Forms of Input

All cells in the PS NHV-HEA worksheets that are intended to receive input values are highlighted in yellow. Three forms of input are requested in the worksheets when evaluating habitat indicators: (1) 'yes' or 'no' answers that are used to characterize pre-project and post-project habitat conditions, (2) the size of an area, such as the aquatic habitat area lost to fill (e.g., boat ramps, bulkheads, etc.), and (3) percent, such as the percentage of the length of the shoreline that is considered fully functional. Detailed explanations for each entry field in each worksheet are provided below in section 2.3. "Data Entry" of this document and in the worksheets within the PS NHV-HEA.xls master program file used to conduct the analyses.

The affected areas evaluated in each assessment zone and worksheet are either calculated by the model from area inputs the user provides or can be directly entered. For the RZ, the affected area is the sum of the areas of the different riparian habitat types (Worksheet "RZ", cell E 18). The area of CH permanently affected in the USZ is directly entered by the user in the USZ worksheet; Worksheet "USZ", cell C6:

'Length (along shoreline) of area affected in the long term by project', and C7 'Width of Upper Shore Zone', again area impacted in long-term by project. Generally, this area is a rectangle including the affected shoreline length by width. If the affected area cannot be approximated with a rectangle, the user can enter the area directly in cell D6. This affected area may be different from the action area used in section 7 consultations. For example, whereas the action area includes the extent of all construction effects, like underwater noise impacts from pile driving to southern resident killer whale, the affected area considered when determining impacts to PS Chinook and HC summer-run chum using HEA and the NHV model includes the projected area of permanent habitat impacts only. For the LSZ and DZ, the model calculates affected areas by adding the area of the structures like, pilings, boats, and floats plus a buffer. The user enters the area of these structures and applicable buffers in the "Shade Impact LSZ" and "Shade Impact DZ" worksheets that are also contained within the master Excel file, PS NHV-HEA.xls

Habitat Equivalency Analysis requires habitat values to range between 0 and 1. The maximum habitat value that can be reached in the USZ and LSZ is 1. Both zones can provide prime rearing conditions for juvenile Chinook. In contrast, the maximum habitat values for juvenile PS Chinook and HC summer-run chum of the RZ and the DZ are lower. The maximum habitat value in the DZ is 0.3. While the DZ provides important migratory and rearing habitat, due to its depth (deeper than 10 feet MLLW) and lack of Submerged Aquatic Vegetation (SAV) it cannot provide as much cover or produce as much food as the USZ, the LSZ. The importance of SAV, in particular eelgrass and kelp, for food-production and cover for juvenile salmonids is documented in Simenstad (2000), and Shaffer (2003). The maximum habitat value for the RZ is 0.55. This value is less than the maximum NHV of 1 for habitat in the USZ and LSZ and more than the 0.3 for the DZ. The rationale is that the USZ and LSZ each provide prime CH for juvenile Chinook (the "gold standard"), and while the riparian zone is not directly used by salmon, it provides essential functions that allow the USZ and LWS to reach their full habitat value. The riparian zone provides extremely important functions for PS Chinook and chum, including shade, input of LWM, input of sediment, and food (Simenstad 2000, Toft et al. 2007, Duffy et al. 2010) and thus can receive a higher maximum habitat value than the DZ.

2.2.2 Riparian Assessment

As mentioned briefly in section 2.1 the analysis of the RZ is designed as a catalogue approach modeled after Iadanza (2001), rather than a site-specific semi-quantitative evaluation of habitat indicators as in the USZ, LSZ, and DZ worksheets of the NHV model. We chose this approach, because for most nearshore projects that NMFS consults on during section 7 consultations, the marine riparian habitat conditions can be grouped into four different categories 1) native trees[2]; 2) native shrubs; 3) herbaceous vegetation or invasive vegetation; 4) impervious surface including pavers, gravel, concrete, decks. The habitat values associated with these conditions range from 0 for impervious surface to 0.55 for trees. Three discounting factors can reduce these habitat values: 1) distance between riparian vegetation and

[2] A tree is a woody plant having one erect perennial stem (trunk) at least three inches in diameter at a point 4-1/2 feet above the ground, a definitely formed crown of foliage, and a mature height of at least 13 feet. http://forestry.usu.edu/htm/treeid/what-is-a-tree-youth/

shoreline; 2) structures between vegetation and shoreline; 3) disconnection of vegetation from USZ via shoreline armoring. The habitat values used for the RZ HEA are an area weighted average over the four different habitat types.

The RZ for this model includes 50 feet laterally landward of the highest astronomical tide line (HAT)[3]. In some areas woody vegetation grows waterward of the HAT. This zone is to be included in the evaluation within the RZ worksheet. Thus, the breaking point in elevation between the assessment zones of the RZ and the USZ areas is the HAT or the lowest point of woody vegetation.

We chose a relatively narrow riparian corridor of 50 lateral feet (~15 m) from the HAT line for riparian assessment purposes because this band of the marine riparian zone provides the majority of riparian functions to the marine nearshore that are of relevance to PS Chinook and HC chum early marine viability (e.g., terrestrial insect contribution, wood and sediment recruitment). For example, trees are more likely to end up in the USZ if they are within 15 m of the HAT compared to trees further away from the HAT. In addition, in our experience, a wider zone is not available for functional riparian enhancement in most residential and industrial settings.

Also, ecological equivalency between USZ, LSZ and the RZ can be supported easiest for a narrow riparian zone. As referenced in Chapter 1, *ecological equivalency* implies that the restored habitat must fully compensate for the functions lost from impacted habitat. Strange et al. (2002) explain, that the underlying assumption of HEA is that the public will accept a one-to-one trade-off between a unit of lost habitat services and a unit of restoration project services. Note that there is not necessarily a one-to-one trade-off with respect to quantifiably impacted resources, but rather in the services the habitat in the overall affected area provides for the species affected—in this case, for the early marine survival and viability of PS Chinook and/or HC summer chum salmon.

Under the assumptions of ecological equivalency, riparian functions, including water quality, shade, forage (e.g., terrestrial insects), forest litter, and large wood recruitment to the intertidal zone, can provide services equivalent to the USZ and LSZ for enabling PS Chinook salmon and/or HC chum salmon to successfully survive through their early marine life history stage. Obviously, the riparian zone itself does not provide a migratory corridor or rearing habitat as fish cannot swim in the riparian zone, but rather can improve the functions the USZ and LSZ can provide. Finally, while we recognize that larger riparian buffers provide habitat functions and ecological services that are also of value for juvenile salmon using the marine nearshore (Brennan, 2007; Brennan et al., 2009), we limited the riparian zone assessed to 50 feet to limit the possibility of losing migratory corridor and rearing habitat in the intertidal zone from project developments if such impacts were mitigated for with proposed riparian zone improvements beyond 50 feet from the extreme high tide line. Such mitigation would have increasing uncertainty to deliver functional value to PS Chinook and HC chum, because of the reasons

[3] The HAT is the tidal elevation of the highest predicted astronomical tide calculated to occur at a specific tide station after the most recent 18-yr Tidal Datum Epoch (TDE) is over. The most recent TDE for which a complete record can be obtained is from 1983 to 2001. The HAT, and relative difference from MHHW and MHW for tidal stations in Puget Sound are appended in Table A-1 for reference.

detailed above; the closer to the HAT a tree, the more likely it is to provide LWM, litter, and terrestrial insects to the USZ.

2.2.3. Upper Shore Zone, Lower Shore Zone, and Deeper Zone Assessments

The breaking point in elevation between the assessment zones of the USZ and LSZ in our model, +5 ft MLLW, approximates the lower limit of forage fish spawning (Pentilla 2007) and the upper extent of eelgrass growth (Mumford 2007). As depicted in Figure 1, the separation of the LSZ and the DZ used for this model is the lowest elevation of either: (a) (-10) feet MLLW, or (b) the lowest elevation of macroalgae growth (macroalgae growth is evaluated in the USZ and LSZ, only). The DZ extends to -98 feet MLLW (-30 meters), the lower limit of listed PS Chinook salmon and HC summer-run chum salmon CH (70 FR 52630 at 52664; September 2, 2005).

Indicators of physical habitat function in the USZ, LSZ, and DZ are awarded points between 0 and 4 for each assessment question, by the model (i.e., these values are not and hardly ever should be input by the user). Indicators most strongly associated with at least one of the PCEs assessed receive a maximum score of 4, indicators strongly associated with at least one of the PCEs assessed receive a maximum score of 3, indicators moderately associated with at least one of the PCEs assessed receive a maximum score of 2, indicators little associated with at least one of the PCEs assessed receive a maximum score of 1, and indicators not associated with any of the assessed PCEs receive a score of 0. For example, based on consideration of the best available science[4], the NHVs workgroup concluded that for the USZ, the "Shoreline Condition" (stabilized vs. naturally functioning) has strong association with the PCEs of food and cover and gave it a score of 3 (*see* detailed discussion below, "Documentation of Indicators"). The "Shallow Water Habitat, Accessibility and Presence" in the USZ provides the strongest association with the PS Chinook marine PCEs. When the upper shore zone area is not impacted by structures, its mere presence for food production, cover, refuge from deeper water areas, and availability as migration corridor receives a maximum score of 4. Functions that are still important for PCE viability for juvenile Chinook, but of a lesser magnitude, like substrate and water quality, receive a lower maximum score.

To derive the NHV for a subject site, the sum of the points awarded for each "Indicator of Physical Habitat" for each the USZ and LSZ is divided by the maximum possible points for the zone. This normalization exercise expresses the NHV for each of the zones as a percentage of the maximum possible habitat value, 1. For the DZ, sum of the "Indicator of Physical Habitat", is divided by 20 to normalize the NHV to a maximum of 0.3 (0.3=6/20). The pre and post-project NHVs are summarized by shore zone in a "Summary" worksheet in the master program file (PS NHV-HEA.xls). The "Summary" worksheet links to the zone-specific NHVs and the HEA worksheets within the master program file.

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Moreley et al. (2012) found that epibenthic invertebrate densities were over tenfold greater on unarmored shorelines in the Duwamish estuary and taxa richness double that of armored locations..

2.2.4. Physical Habitat Reduction Factor Assessment

For some indicators of physical habitat the initial scores are multiplied by a reduction factor depending on variables that influence these functions. For example, shading from OWS and substrate disturbance from prop scour reduce the primary production and cover that SAV can provide to juvenile salmon (Burdick and Short 1999, Shaffer 2002, Fresh et al. 2006). Thus, each of the scores, for primary productivity (in the DZ) and aquatic vegetation (in the USZ and LSZ) is multiplied with a reduction factor derived from the amount of shading and/or prop scour estimated from the project description. Further, shading from OWS has been shown to interrupt the migratory path of juvenile salmon (Heiser and Finn 1970, Simenstad 1999, Southard et al. 2006, Toft et al. 2007, Ono 2010). This adverse effect of shading (see detailed discussion below, "Documentation of Indicators", Section 3.0) is captured by applying a reduction factor from the amount of shading (not including prop scour) to the score awarded for area of "Shallow Water Habitat, Accessibility and Presence".

To derive the two physical habitat quality reduction factors, shading and prop scour, the user needs to fill out the "Shade Imp USZ" and "Shade Imp LSZ" worksheets, also contained with the PS NHV-HEA.xls spreadsheets. First the user enters the areas of the OWS to be evaluated, such as boats, floats, their buffers in square feet (column B for before and F for after), and the percent shading associated with each element (column D for before and H for after). The model then calculates an area weighted average of shading over the impacted area assuming that for completely shaded areas a 10 percent habitat value remains. This assumption of a 10 percent residual value for SAV and primary production stems from two considerations. First, non-light dependent processes, including bacterial production, occur regardless of shading. Second, most structures NMFS has reviewed are narrow, less than 10 feet wide or elevated, and allow for some scatter of light into areas underneath solid cover.[5] For example, if 80 percent of an affected area is shaded, the habitat impact is calculated as 72 percent (80*.9 = 72). The reduction factor is 1 minus the impact which results in the remaining habitat value: 0.28 = 1-0.72. The reduction factor used for the aquatic vegetation and primary production is 1 minus the area weighted average of the impacts of all shaded areas, buffers, and areas impacted by prop scour (cell C 18 before and D18 after). For impacts to unobstructed migratory pathways the reduction factor applied to "Habitat Accessibility and Presence" is calculated using shaded area, only, not prop scour. The prop scour, while potentially impacting to vegetation and sediment, is, in residential settings, generally too short-term to be of much impact to migration and habitat use. Further, the reduction factor applied to "Habitat Accessibility and Presence" in the USZ and LSZ is 60 percent of the weighted average of un-shaded area, only, because best available science has demonstrated that shading from OWS can be a migratory deterrent for juvenile salmon in the PS nearshore, but does not create a complete migratory barrier like, for example, a jetty would (Simenstad 1999, Southard et al. 2006). Southard et al. (2006) report that while juvenile salmon were observed most frequently within 10 meters of the edge of ferry terminals, some were observed underneath.

The impact of shading on unobstructed juvenile migration in the DZ habitat is less than in the USZ and the LSZ. First, juvenile salmon are thought to increase in size with the depth they are found to utilize. For

[5] For evaluating wider OWS like some ferry docks this part of the model may have to be changed.

example, Duffy et al. (2005) notes, “While there is not conclusive evidence for a fixed size threshold for salmon at different habitats, body size increases progressively from delta to nearshore to offshore (shallow to deep) waters”. This finding suggests that juveniles are larger when inhabiting the DZ (deeper than minus 10 feet MLLW or deeper than the deepest on-site SAV), faster swimmers and better able to avoid predators than smaller size juveniles in the USZ and LSZ. Second, this model is built for quantifying impacts from structures in the DZ like boats tied to mooring buoys and floats accessed via elevated piers and ramps. Juveniles can swim around these structures without being exposed to much change in water depth. If for example a float is moored at – 11 MLLW, the water depth at a very low tide is already close to 10 feet, not offering any of the around one foot shallow water that small juveniles inhabit. Swimming around the structure in the DZ may change the water depth a juvenile experiences by around two feet. At a water depth of around 10 feet or more, we think change of two feet depth due to swimming around the OWS, is not as detrimental as it is for a small juvenile to leave the shallow water in the USZ, or LSZ. Many biologists suggest that if juvenile salmon have to utilize deeper water to swim around OWS, they are at higher risk from piscivorous predation (Nightingale and Simenstad 2001, Willette 2001)[6]. Thus, the version of the NHV model built for quantifying impacts from small OWS uses a smaller reduction factor for impacts from OWS shading to the to “Habitat Accessibility and Presence” in the DZ than in the USZ and LSZ[7]. The “remaining habitat value” factor applied to the “Shallow Water Habitat and Accessibility” project points is for the LSZ and the USZ: 1 - average shading over the entire area *0.6; for the DZ: 1 - average shading over the entire area *0.3.

Willette (2001) found that juvenile pink salmon in Prince William Sound move from the shallow nearshore into deeper water following their prey. With the juvenile pink salmon foraging in deeper water, the mean daily individual predator consumption of salmon increased by a factor of five.

[7] For solid OWS that span the LSZ, DSZ and reach into the DZ, the same reduction factor of 0.6 as for the LSZ and USZ should be used, because there is no possibility for juveniles to continue their migration by swimming landward around the DZ portion of the OWS without having to access deeper water.

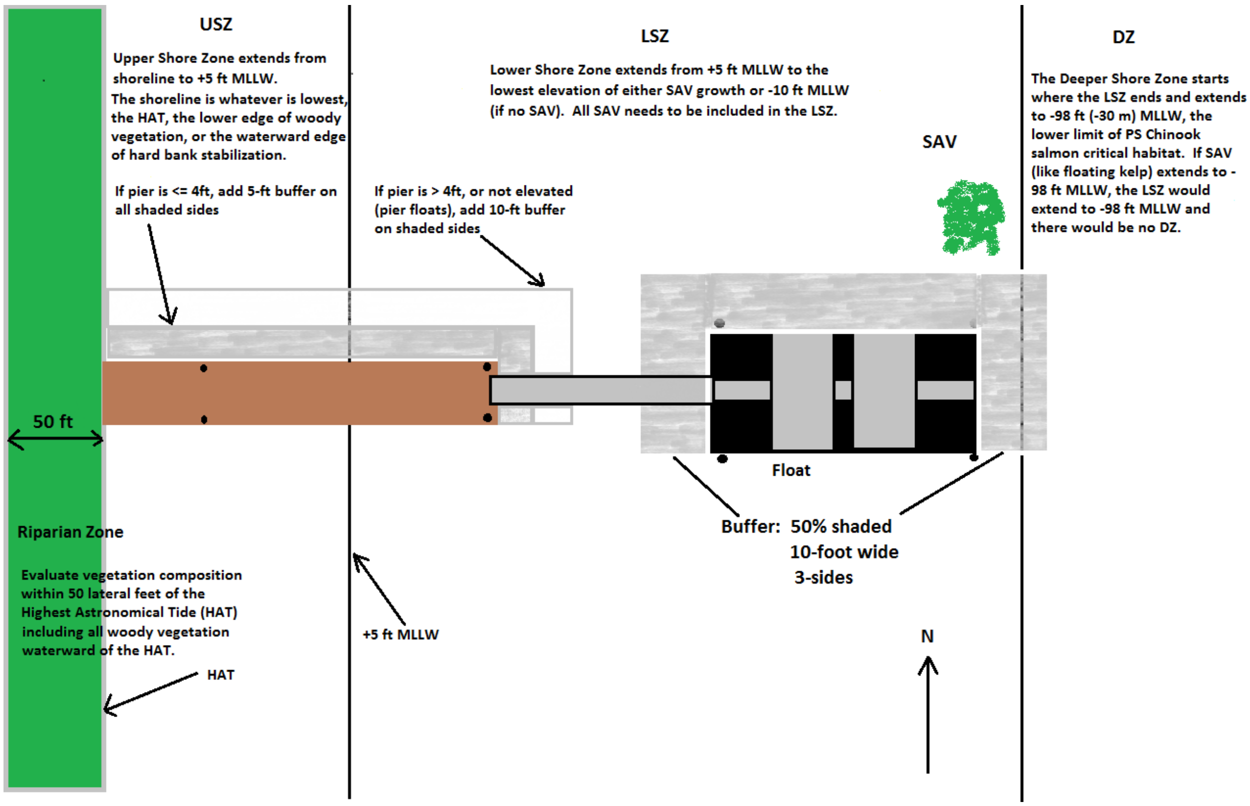

Figure 1. Conceptual depiction of different zones defined for the NHV model and a typical pier-ramp-float.

2.2.5. Discounting/Crediting Factors

Final project-related ecological gains or losses are expressed as Discounted Service Acre Years (DSAY's) and are calculated using the HEA. For certain habitat conditions these DSAYS are multiplied by an overall crediting or debiting factor in the final HEA worksheet within the master program file. This approach of using crediting/debiting factors at the end is used to account for the fact that the same habitat can be more valuable to PS Chinook or HC summer-run chum if certain conditions apply.

The first crediting/discounting factor is forage fish spawning habitat. A habitat area documented to support forage fish spawning contributes significantly more value for PS Chinook and HC summer-run chum, in terms of its food production, compared to identical habitat that is not used by forage fish for spawning.

The second crediting/discounting factor we use for PS is delta/estuaries. Redman et al. (2005) reason, that the area closest to natal deltas, within five miles, is important to juveniles to aid in transition from delta to shoreline habitats. Further the area close to natal deltas is likely to have high concentrations of juveniles. For HC summer-run chum the literature also specifically supports that the estuary and adjacent nearshore areas are important for fry survival (reviewed by Johnson et al. 1997 and (Brewer et al., 2007). However, it is difficult to determine how far the most critical nearshore adjacent to natal estuaries extends. Schreiner (1977) reports that HC chum maintain a nearshore distribution until they reach a size of 45-50 mm, at which time they move to deeper offshore areas. However, the literature does not allow determining at what distance from the natal river this size may be reached. Bax et al. (1978); (Bax et al., 1979) suggest that in addition to size there are other factors that influence HC summer chum dispersal into deeper water. With a slightly different view, Johnson et al. (1997) summarize that some chum fry remain near the mouth of their natal river when they enter an estuary, but most disperse within a few hours into tidal creeks and sloughs up to several kilometers from the mouth of their natal river. Brewer et al. (2005) prioritize recovery actions for HC summer chum within one mile of the natal estuaries (chapter 3.5). We, in turn, have anecdotally observed extensive use of the shallow marine nearshore by recently emigrated chum fry in the spring months five miles and further from their natal stream of origin in southern PS.

In an attempt to determine a reasonably conservative and operationally workable approach, NMFS determined that the crediting factor of 1.5 applies to all areas within a 5 mile radius of the natal PS Chinook salmon and HC summer-run chum estuaries. This approach assigns additional habitat value to most of the areas that are relatively more important for early HC summer chum rearing than other nearshore areas and described by Brewer et al. (2005) as one mile, Johnson et al. (1997) as several kilometers, Redman et al. (2005) as five miles, and our personal unpublished observations. Based on this information, the nearshore PS HEA model assumes that habitat is more valuable to juvenile Chinook and for HC summer-run chum when within 5 miles of a natal estuary, compared to identical habitat in a different location. Thus, PS nearshore habitat would be credited within 5 miles of all systems in PS recognized to support PS Chinook salmon or HC summer-run chum salmon.

The third crediting factor used for PS is based on the Skagit River System Coop research. Beamer et al. (2003, 2006, and 2007) showed that pocket estuaries provide important rearing habitat for juvenile Chinook, especially early in the year, once they leave their natal estuary. Further, Beamer and Fresh (2012) found that in the San Juan Islands, juvenile Chinook were most abundant at bluff backed beach and pocket beach shoreline types.

Thus, the final DSAY value is multiplied by 1.5 if any of these conditions that render a habitat especially valuable apply: (1) affected area is located within documented or potential forage fish spawning habitat; (2) affected area is located within 5 miles of a natal PS Chinook or HC summer-run chum delta/estuary; (3) the affected area is located within a pocket estuary or bluff backed beach.

2.2.6. Sensitivity Testing

At end of developing a NHV model prototype, we performed sensitivity testing (Appendix 2). to verify that the habitat values the NHV model assigned to different before/after scenarios and the maximum habitat values that can be provided by each zone seemed reasonable and were in a range of what could be expected. Documentation for these sensitivity tests is included in Appendix 3.

We are aware that this sensitivity testing merely provides a check of the results against expert opinion. While the biological rules the model is based on are well established and supported by literature, also see section 3.0, the quantitative interpretation of these biological relationships between habitat quality and fish response are mere working hypotheses. A field test of the quantitative interpretation of the functional relationships for physical habitat indicators remains to be performed. In other words, it is well established that juvenile salmon need the nearshore for early rearing. What we don't know is exactly how much their productivity would be reduced by eliminating a certain amount on nearshore habitat with bulkheads. This specific question is difficult to answer. And, as with many habitat models, field testing the validity of the values (1 through 4) assigned to different habitat conditions will require intensive studies. For example, testing the value of different SAV conditions could involve: (a) choosing an appropriate response variable like number of juvenile salmon, (b) monitoring the number of juveniles (response variable) in the proposed five different SAV habitat conditions.

2.3 Nearshore Habitat Value Data Entry and HEA Calculations

This section walks the reader through the data entry for each of the four habitat zones evaluated in the PS nearshore HEA model. Some central tenets to remember when filling in cells in each of the worksheets:

- Enter all length measurements in feet.
- Enter all areas in square feet.
- Enter all percent values as numbers between 0 and 100.
- Fill in yellow-highlighted cells only.
- The worksheets contain notes, shortened manual text, to guide your entries.

2.3.1 Riparian Zone Evaluation Worksheet and Data Entry

The riparian zone assessment worksheet (RZ) in the master program Excel file (PS NHV-HEA.xls) evaluates habitat conditions in the adjacent upland riparian zone of the proposed in-water structure, by examining conditions within 50 landward feet of the HAT. The waterward extent of the riparian zone, the shoreline, is the lowest elevation of naturally growing vegetation[8] or the stabilized shoreline in altered conditions.

[8] The lowest extent of woody vegetation is dependent on site conditions including parameters like salinity, elevation, and soil conditions. Guthrie (2012) found that in the Nisqually River tidal wetlands elevations located below a depth of ⅓ m above mean higher high water did not support woody plant growth.

1. If the subject proposal does not include any changes to the riparian area enter “0” square feet for 1a through 1d for before-project (column E) and after-project (column G) conditions.
2. For projects that have a riparian component enter, enter the area of each type of vegetation within 50 feet of the HAT, trees, shrubs, herbaceous vegetation, and impervious surface (1a, 1b, 1c, 1d) for before and after project implementation in columns E and G.
3. For the RZ worksheet to accurately evaluate the site condition the shoreline condition on the USZ worksheet needs to be filled in reflecting the site conditions at the interphase of the RZ und USZ, see 4.c. below.
4. Discounting Factors. Three conditions listed below reduce the habitat value of the riparian vegetation:
    a. Distance between riparian vegetation and shoreline: *see* Row 16. In our model, the further vegetation is away from the water’s edge the fewer functions (e.g., sediment and wood recruitment, terrestrial insect contributions, leaf fall) it is presumed to provide. To quantify this concept we assumed that vegetation planted 50 feet away from the water’s edge (i.e., at the border of the 50-foot wide assessed riparian corridor), contributes 30 percent function. Whereas vegetation planted immediately next to the water’s edge contributes 100 percent. For riparian vegetation planted at distances in between 0 feet and 50 feet away from the waters’ edge the discounting factor for the function the vegetation provides is in between 100 percent and 30 percent and calculated with a linear function:
    DF_{dist}= 0.3/50[ft]*D_V[ft]
    DF_{dist} : discounting factor (distance)
    D_V[ft]: distance of vegetation to waters edge
    b. Structures between vegetation and shoreline: *see* Row 17. Structures such as buildings and boathouses that are placed between the vegetation and the USZ reduce the functionality of the vegetation by reducing connectivity to the USZ. They reduce the input of allochthonous material and LWM. As height, structure type, and length impact how much a structure disconnects the vegetation, the user needs to calculate the percent of reduction. A 90 percent reduction would result when a solid wall disconnects the entire length and height of the existing riparian vegetation from interacting with the USZ such that few functions otherwise obtainable are reasonably certain to deliver to the marine nearshore. The only functions that may remain would be some insects still reaching the USZ and water reaching the USZ being filtrated. To completely disconnect herbaceous vegetation the wall would have to be a few feet high. If 50 percent of the biomass of trees overhang the wall we have presumed25 percent function would remain for input of allochthonous material (not 50 percent as most likely no LWM would enter the USZ).
    c. Disconnection of riparian vegetation from the USZ via shoreline armoring: *see* Row 22, Cells D22 (before), E22 (after). Note: these cells are linked to the Shoreline Conditions

question in the USZ worksheet. If the riparian area is disconnected from the USZ by shoreline stabilization, a discounting factor of 0.5 is applied to the vegetation habitat value. This is based on the fact that little wood will reach the USZ from behind a bulkhead and organic and insect inputs are reduced compared to unstabilized shoreline settings.

5. Row 18: The affected area needs to be the same for before and after: E17 = G17
6. Cell I18: calculates an area weighted average of the duration till vegetation is mature plus the years of time delay between impact and riparian restoration (D27)[9].

2.3.2 Upper Shore Zone Evaluation Worksheet and Data Entry

This part of the analysis evaluates habitat conditions along the shoreline of a project area from +5 MLLW to the lowest elevation of woody vegetation, or in the absence of woody vegetation, the HAT line, whichever is lowest. If the USZ is separated by armored shoreline, the upper extent of the USZ would extend to the waterward boundary of the armoring (e.g., *see* Figure 1). The USZ is evaluated in the master program file (PS NHV- HEA.xls) through two worksheets, 'USZ' and 'Shade Imp USZ'. Both worksheets must be completed, as detailed below.

"USZ" Worksheet

1. The user enters the affected area by filling out cells C6 and C7:
   a. C 6 Enter the length (along the shoreline) of area affected in the long term by the proposed project. For structures that impede drift patterns, like boat ramps, jetties, and rails, the affected length along the shoreline likely includes a portion of the downdrift part of the drift cell. For piers:
      add no buffer if they are elevated, fully grated and ≤ 4 ft wide;
      add a standard 5-ft buffer on all but the North side if they are elevated, not fully grated and ≤ 4 ft wide;
      use 10-ft buffer on all shade receiving sides if pier is wider than 4 feet. Also, for structures that are not elevated use a 10-ft buffer on all shade receiving sides (i.e., except the North).
   b. Enter the width of Upper Shore Zone that you expect to be impacted in the long-term by the project. Often this is the area from the waterward edge of shoreline stabilization to +5 MLLW. However, if no shoreline stabilization is present the extent of project impacts will determine the upper assessment line. The most landward extent that the USZ can extend to is to the start of woody vegetation or the HAT line, whatever is lower.
   c. The area affected by the project is automatically calculated in D6 with the inputs from D6 and C7. However, if the affected area does not resemble a rectangle, the user may enter the size of the affected area directly in Cell D6.

[9] This is a simplification that for the short delays usually occurring for these nearshore projects is a close approximation for the more accurate calculation of delaying the onset of mitigation. As time allows we will include the more accurate calculation in the next version.

2. Evaluation of Indicators of Physical Habitat:
    a. <u>1. Shoreline Condition.</u> Enter what percent of bankline of the action area is in undeveloped natural bank conditions, E12 (before) and H12 (after). For a completely bulkheaded bank in the affected area enter a 0. For bioengineered banks enter overall percent of function compared to unstabilized, natural shoreline. When determining the percent function of a bioengineered bank consider: (1) the location of the toe of slope, whether the bioengineered design reduces the amount of shallow upper intertidal that would have been available under natural conditions, (2) the slope; and (3) the percent of hard vs soft material in the bank. The project points (cells F12 (before), I12 (after)) are calculated by multiplying the percent function of the shoreline condition with the maximum possible score (displayed in column D).
    We would appreciate your pictures of different shoreline conditions. We are planning on assembling a catalogue with pictures and descriptions of different functionalities to guide user assessment. Only send pictures you are ok with being used publically. We will of course credit the photographer and author.
    b. <u>2. Shallow Water Habitat.</u> Here the mere presence/absence and accessibility of juvenile Chinook and HC summer-run chum shallow water rearing habitat is evaluated. Enter what area of USZ shallow water area is lost to juvenile rearing (cells E14 (before), H14 (after)). This loss could be the result of the construction of three-dimensional structures that result in the loss of shallow water habitat during some tides. Such structures include pilings, bulkheads, jetties, and fill. Also, shallow water habitat loss could be the result of a conversion of shallow water habitat to deep water habitat via dredging. Not included as impacts to this habitat parameter are low profile structures like boat ramps, rails, and low concrete rubble. The effect of boat ramps and debris are considered with the substrate rating below.
    The area occupied by three-dimensional structures or dredging should be calculated by the analyst and entered in square feet.
    E 15: If the loss to shallow water habitat is a result of dredging, enter the area in E14 and a "Y" in E15. When nearshore areas are dredged, 30% of habitat points are awarded to account for that the habitat is not completely gone, but converted to deeper habitat.
    <u>Row 16</u>: A discounting factor is applied to the project points awarded for the presence of unobstructed shallow water habitat, if shading from OWS or prop scour impacts are part of the project, see "2.2.4. Physical Habitat Reduction Factor Assessment" above for an explanation of the concept and "Documentation of Indicators" below for the supporting biology. This discounting factor, E16, is calculated in the "Shade Imp USZ" worksheets, see below.
    c. <u>3. Beach Logs and Wrack.</u> Enter the percent of function that beach logs provide compared to the ideal, best case scenario for the affected area, E18 (before) H18 (after). Depending on fetch, slope of the beach, wood supply, and current regime, the natural wood loading can be vastly different between sites. The NMFS team could not find

reference literature as to the natural wood loading on upper beaches in PS. Until there is more information on this habitat parameter, it is up to the biologist and consultant preparing the Biological Assessment to research what natural wood loading in the affected area most likely would have been and compare current and proposed site condition to the assumed natural wood loading.

If there is no project related change in the wood loading, the quality of the estimate is not critical as the (before) E18 and (after) H18 percentage will be the same.

We would appreciate your pictures and assessments of different shoreline wood loading. We are planning on assembling a catalogue with pictures and descriptions of different functionalities to guide user assessment. Only send pictures and descriptions you are ok with being used publically. We will of course credit the photographer and author.

d. 4. Substrate/Sediment. Enter a “Y” for which of the three substrate description a) > 25 percent mud or mixed fines, E20 (before), H20 (after); b) >25 percent sand or gravel, E21 (before), H21 (after); c) > 25 percent rocky E22 (before), H22 (after); best matches the surface layer at the site.

Discounting Factors 4d, 4e, 4f:

4d/Row 23: The project points awarded for the habitat value that the substrate provides are reduced if sediment is covered up by low or high profile structures, including boat ramps, riprap, rubble, jetties, pilings, and bulkheads. If all sediment in the affected area is covered, 0 project points are awarded for sediment.

4e/Row 24: Often shoreline stabilization projects result in substrate being unnaturally compacted or coarsened and/or the beach grade being lowered. When waves reflect off shoreline armoring structures, particularly vertical hard bulkheads, they can erode sediments, and lead to beach ‘hardening’ and narrowing (Sobocinski 2003, (Dugan et al., 2011; Dugan et al., 2008) Shipman 2009). Such outcomes permanently impair the ability of the habitat to support forage fish spawning and provide salmon prey, resulting in adverse, indirect effects to PS Chinook and HC summer-run chum salmon (Rice, 2006) (Morley et al., 2012). Morley et al. (2012) observed that armored sites in PS provided less benthic prey for chum than armored sites. These negative effects to sediment can be evaluated in this part of the model. Consider effects within the affected area[10], only. To estimate what the effect of a new structure would be, it is helpful to consult reference sites. Enter the percent reduction in cell E24 for before conditions and cell H24 for after project conditions.

4f/Row 25: If there is little macroalgae/SAV or saltmarsh vegetation cover, primary production from algae in the sediment (like diatoms) or algae mats can have substantial contributions to the food chain. Just like primary production in SAV, the primary production of algae associated with the sediment will be negatively affected by shading. A discounting factor is applied to the project points awarded for sediment habitat

[10] The affected area is the area calculated in D6 from user entries in cells C6&C7.

quality if the vegetation cover is below 40 percent. The discounting factor is displayed in cell E25 (before) and H25 (after) and is calculated in the "Shade Imp USZ" worksheets, see below.

e. <u>5. Vegetation.</u> At an elevation of +5 MLLW and above we expect to see no eelgrass or kelp. Do not include drift *Ulva sp.* and *Enteromorpha sp*. when determining what score to award for this habitat condition.
<u>5a/Row 27:</u> Enter "Y" in cells E27 (before) and H27 (after) if your affected area is covered with more than 60 percent of any combination of upper intertidal vegetation.
<u>5b/Row 28:</u> Enter "Y" in cells E28 (before) and H28 (after) if your affected area is covered with less than 60 percent of any combination of upper intertidal vegetation.
<u>5c, Discounting Factor/Row 29:</u> The habitat value of vegetation is negatively affected by shading and prop scour. Thus, a discounting factor is applied to the project point awarded for vegetation habitat quality if shading and/or prop scour affect the affected area. This factor is calculated in the "Shade Imp USZ" worksheets, see below.

f. <u>6. Water Quality.</u> Enter "Y" in column E for whichever described condition best fits the affected area. For many projects no specific water quality data are available. Using a surrogate approach is appropriate and supported by PS-wide studies. For example Lanksbury et al. (2014) found that the highest levels of contaminants tested for in the PS nearshore occurred in the urban and industrial bays.
Further, consider that this is a small scale assessment of water quality, within the affected area, only. At this scale the addition of a pier, ramp, and float can be expected to result in a reduction of water quality by one category, from optimal to medium or medium to poor. This reduction can be attributed to a combination of contaminants from the structure including zinc from zinc coated metal, leachate from treated wood, and hydrocarbons from boat use. The removal of few creosote treated piles can be expected to have a positive effect and should increase the awarded water quality score by one or two points, depending on magnitude of removal effort per area.
Below we detail standard assumptions for the removal of ACZA and creosote treated pilings that NMFS uses:
For USZ:
cell C6&C7 enter 10 ft each resulting in an area of 100 sq-ft of affect area for 1 pilings
Shade Imp USZ: enter number and size of pilings I B25&26 (before) and D 25&26 (after). This will result in the area occupied by the pilings being reflected in the USZ worksheet in row 2a Shallow Water Habitat Accessibility and Presence and row 4d Habitat Loss from Development.
No change in physical habitat parameters: shoreline conditions, Beach Logs, Substrate Size, and Vegetation.
Record water quality improvement of 1 point within affected area (from contaminated to medium) for removal of ACZA-treated posts, of 2 points for removal of creosote treated pilings.
In an area with no crediting or discounting factors this results in 0.1 DSAYs for the

removal of 10 creosote pilings and of 0.5 DSAYs for the removal of 10 ACZA-treated pilings.

2.3.3 Lower Shore Zone Evaluation Worksheet and Data Entry

The Lower Shore Zone extends from +5 ft MLLW to the lowest elevation of either SAV growth or -10 ft MLLW (if no SAV). All SAV needs to be evaluated in the USZ and LSZ portion of the listed CH for PS Chinook and HC summer run chum. The DZ portion of the model is not set up to evaluate SAV.

In some cases the elevation in front of shoreline stabilization has been lowered to below +5 feet MLLW, or shoreline structures, like bulkheads, have been built out into the LSZ. In these cases, if the affected area includes proposed action elements that affect the "Shoreline Condition" and/or "Beach Logs" (which are evaluated in the USZ worksheet, only), the user will have to use the USZ worksheet for intertidal areas adjacent to a shoreline with elevations below +5 feet MLLW.

LSZ Worksheet

1. Different from the USZ, the LSZ worksheet of the model determines the affected area via the "Shade Imp LSZ" worksheet, see below. The user does not need to enter an affected area. The affected area is calculated via the construction/restoration elements the user enters.
2. Evaluation of Indicators of Physical Habitat:
    a. <u>Aquatic Vegetation.</u> The following descriptions give reference points for evaluating macroalgae habitat value for juvenile Chinook and HC summer-run chum. The parameters used to determine increasing/decreasing SAV habitat value for Chinook are size and structure that the aquatic vegetation provides combined with areal coverage. As with vegetation in the USZ, imagine the described conditions to be on a continuous macroalgae value scale. There will be cases when a given site falls in between described scenarios. There is too much variability in macroalgae conditions to capture them all in the descriptions. For site conditions that lay distinctly between described scenarios, the user may assign values in 0.5 increments and enter the determined number in cells F10-14 and I10-14.
    <u>1a/Row 10</u>, Cells E10 (before) and H10 (after). Answer "Y" if the affected area is covered with more than 75 percent combined areal coverage of kelp beds, eelgrass beds, *Laminaria sp.* beds, or other dense beds of aquatic vegetation higher than 6 inches that provide structural diversity.
    <u>1b/Row 11</u>, Cells E11 (before) and H11 (after). Answer "Y" if the affected is covered with more than 50 to 75 percent combined areal coverage of kelp beds, eelgrass beds, *Laminaria sp.* beds, and other beds of aquatic vegetation higher than 6 inches that provide structural diversity, or 75 percent-100 percent of any other aquatic vegetation, not counting *Ulva sp.* and *Enteromorpha sp.*[11] Also, answer "Yes" if area is covered by

[11] While Ulva sp. and Enteromorpha sp. provide habitat, their locally increased abundance sometimes in response to increased nutrients has been documented to reduce fish biodiversity and reported to reduce eelgrass abundance Schein, A., S.C. Courtenay, C.S. Crane, K.L. Teather, and M.R. van den Heuvel. 2012. The Role of

native oyster beds.

1c/Row 12, Cells E12 (before) and H12 (after). Answer “Y” if the affected area is covered with 25 percent to 50 percent of combined areal coverage of kelp beds, eelgrass beds, *Laminaria sp.* beds, and other aquatic vegetation higher than 6 inches that provide structural diversity, or 50 percent to 75 percent of any other aquatic vegetation, not counting *Ulva sp.* and *Enteromorpha sp.*, unless it is in the vicinity of areas where these species have been document as herring spawning habitat (e.g.Wollochet Bay). Chose this category when low structure herring spawning habitat of any density is present (e.g. Ulva sp., Gracilaria sp.), including mud.

Example Scenario 1b/1c: award 2.5 points, because coverage and species composition is between what is defined in 1b and 1c:
25 percent *Gracilaria sp*.
40 percent *Laminaria sp*.
10 percent *Zostea marina*

1d/Row 13, Cells E13 (before) and H13 (after). Answer “Y” if the affected area is covered with:
less than 25 percent of kelp beds, eelgrass beds, *Laminaria sp.* beds, and other aquatic vegetation higher than 6 inches that provide structural diversity, or 0 percent to 50 percent of any other aquatic vegetation, or >25 percent of *Ulva sp.* and *Enteromorpha sp.*.

Example Scenario 1d:
25 percent *Ulva sp*.
10 percent *Gracilaria sp*.
5 percent *Laminaria sp*.

1e/Row 14, Cells E14 (before) and H14 (after). Answer “Yes” if the affected area is covered with no vegetation higher than 6 inches, and < 25 percent of even low quality low growing vegetation like *Ulva sp.* and *Enteromorpha* sp..

Discounting Factor Row 15, E15 (before) H15 (after). The habitat value of SAV is negatively affected by shading and prop scour. Thus, a discounting factor is applied to the project points awarded for vegetation habitat quality if shading or prop scour affect the affected area. The discounting factor is calculated in the “Shade Imp LSZ” worksheets, see below. Since this discounting factor quantifies the adverse effects from

Submerged Aquatic Vegetation in Structuring the Nearshore Fish Community Within an Estuary of the Southern Gulf of St. Lawrence. *Estuaries and Coasts*. 35:799-810. Nelson, T.A., A.V. Nelson, and M. Tjoelker. 2003. Seasonal and Spatial Patterns of "Green Tides" (Ulvoid Algal Blooms) and Related Water Quality Parameters in the Coastal Waters of Washigton State, USA. *Botanica Marina*. 46. Frankenstein

OWS, biologists do not need to forecast the reduction in SAV coverage as an effect of the shading from the OWS. If the evaluated impact results from shading and/or prop scour, SAV conditions before and after should be rated as the same. The advantage of this approach is that it eliminates the subjectivity of different biologists potentially estimating different effects on SAV from the same structure. However, if habitat is filled, dredged, or SAV actively removed as a result of the evaluated action, then the before and after rating of the SAV condition would be different.

Herring spawning substrate:

- NMFS biologists felt that eelgrass and kelp provide the "gold standard" value of habitat for juvenile Chinook, regardless of whether it is herring spawning substrate or not. Thus, herring spawning habitat gets accounted for with a crediting factor of 1.5 at the end, when calculating DSAYs in the HEA module.
- If herring spawning takes place on mud, Ulva, or similar low growing vegetation that otherwise would get categorized as 1d (1 out of 4 points), the herring spawn propels it into category 1c (2 out of 4 points), otherwise impacts to this sensitive resource would be undervalued in the model.

Shallow Water Habitat, Accessibility and Presence. Here the mere presence/absence and accessibility of juvenile Chinook shallow water rearing habitat is evaluated. Enter what area of USZ shallow water area is lost to juvenile rearing. This loss could be the result of the construction of three-dimensional structures that result in the loss of shallow water habitat during some tides. Such structures include pilings, bulkheads, jetties, and fill. Also, shallow water habitat loss could be the result of a conversion of shallow water habitat to deep water habitat via dredging, see below. Not included as impacts to this habitat parameter are low profile structures like boat ramps, rails, and low concrete rubble. The effect of boat ramps and debris are considered with the substrate rating below.

Row 19/2c: A discounting factor is applied to the score awarded for the presence of unobstructed shallow water habitat, if shading from OWS and/or prop scour impacts are part of the project; see "Methods" above for an explanation of the concept and "Documentation of Indicators" below for the supporting biology. This discounting factor is calculated in the "Shade Imp LSZ (before/after)" worksheets, see below.

The maximum score possible for this element, "Shallow Water Habitat, Access and Presence" is lower in the LSZ than in the USZ. It is 25 percent of the total possible points for the USZ and 15 for the LSZ. This difference reflects in part, that the USZ provides on average more shallow water rearing habitat than the LSZ.

Dredging: Row 18/2b: If dredging in LSZ is proposed, consider impacts to shallow water habitat from the area dredged between the elevation of +5 MLLW and – 10 feet MLLW, only.

i. Enter proposed area to be dredged in cell E17 (before) and/or H17 (after). This model will copy this entry to the "Shade Imp LSZ" worksheet B13 (before) and F13 (after) and use this area as the affected area.
ii. Dredging cannot be evaluated together with OWS. If new OWS and dredging is proposed, determine impacts separately for each affected habitat area and add DSAYs afterwards.
iii. In "LSZ" worksheet, enter "Y" in cell E18 (before) and/or H18 (after).
For dredging in the LSZ, the model multiplies the awarded points by 0.3 to account for that the habitat is not completely gone, but converted to deeper habitat.
We plan on further developing how the model tracks dredging and appreciate your feedback for our next version.

b. Substrate. Same as in USZ, see above.
c. Water Quality. Same as in USZ, see above.

2.3.4 Deep Zone Evaluation Worksheet and Data Entry

The DZ extends to -98 MLLW feet (-30 meters), the lower limit of listed PS Chinook and HC summer-run salmon CH.

Only three habitat parameters are evaluated, the "Water habitat Accessibility and Presence", "Primary Production" and "Water Quality". The maximum habitat value for the DZ is 0.3 whereas the maximum NHV for the USZ and LSZ is 1. This reflects the reduced importance of the DZ for juvenile Chinook and HC summer chum rearing and the fact that effects of OWS in the DZ have less impact on PCEs. For example, vegetation cannot be impacted, as there is no SAV in the DZ.

Shade Impact DZ: For boats on mooring buoys do not add a buffer as boats move. Buffers in the DZ apply to fixed structures, only.

2.3.5 Shade Impact Evaluation Worksheets and Data Entry

Enter the area of respective elements of OWS in column B (before) and F (after).

For each element of OWS enter associated percent of shading in column D (before) and H (after). For example for fully grated piers assume 10 percent non-grated area covered by structural elements and 40 percent covered by the metal of the 60% open space grating. That would result in a percent shading impact of: $0.46 = 0.1+0.9*0.4$

Buffers:
Add no buffer if pier is elevated, fully grated and $\leq$ 4 ft wide;

add a standard 5-ft buffer on all but the North side if pier is elevated, not fully grated and $\leq$ 4 ft wide; use 10-ft buffer on all shade receiving sides if pier is wider than 4 feet. Also, for structures that are not elevated use a 10-ft buffer on all shade receiving sides (i.e., except the North) Ono (2010).

Prop Scour: Whether prop scour occurs has to be evaluated on a site by site basis. Prop scour is likely to occur in shallow areas if a boat is operated with less distance between SAV or the sediment than the draft of the boat and motor. If no data on the draft of a boat and motor is available use 4 feet (see below "Documentation of Indicators") as the default. An average assumption is to assume that a 10 percent impact occurs if a boat is moored at a float in water shallower than – 2 MLLW.

2.4 Documentation of Indicators

This section provides background and support for the habitat indicators assessed with the PS HEA model, within each worksheet where data entry may occur.

2.4.1 Riparian Zone Assessment—(Worksheet RZ in PS NHV-HEA.xls)

Woody vegetation along the shoreline provides many functions including stabilization of soils, providing food (allochthonous input of detritus and insects), cover for salmon (70 FR 52630 at 52665 September 2, 2005; Brennan 2007, Schlenger et al. 2011), water quality control via filtration of runoff (Desbonnet et al., 1995), and shade for forage fish spawn (Penttila 2007). Terrestrial leaf litter drop feeds aquatic invertebrates (Romanuk and Levings, 2003) which in turn are a food source for Chinook salmon (Duffy et al. 2010). Further, terrestrial insect that drop into the nearshore marine waters directly feed Chinook salmon (Toft et al. 2007, Duffy et al. 2010). Next to insects and marine zooplankton, forage fish are an important part of Chinooks' diet (Duffy et al. 2010). Forage fish spawn in the upper shore zone where shade is important to keep their eggs from desiccation during the summer incubation period (Penttila 2002; (Rice, 2006). Finally, woody vegetation provides a source of marine large woody debris which provides cover and structure for juvenile Chinook in the nearshore and substrate for invertebrates (Tonnes 2008).

2.4.2 Upper Shore Zone Habitat Assessment

Question 1: Shoreline Condition

Natural shorelines provide many important functions for PS Chinook and HC summer-run salmon. In addition to the strictly vegetation related functions, addressed in the riparian assessment, the shallow water along natural shorelines in the upper shore zone provides refuge from predators and a migratory corridor. Stabilized shorelines, to varying degrees, cut off the shallow water regions of the beach. Further, hard bank stabilization has been shown to frequently result in modified wave regime, beach degradation including lowering of beach profile, and coarsening of substrate (Sobocinski 2003, Shipman 2010)Dugan (Dugan et al., 2011; Dugan et al., 2008). All three effects from shoreline stabilization, harsher wave regime, lowered beach profile, and coarser substrate, reduce the suitability for forage fish spawning and their reproductive success. Less forage fish mean a reduce food base for salmon in PS.

Natural shorelines include bluffs, woody vegetation, and wetlands/saltmarshes. Regardless of which geology/vegetation combination is present, literature shows that highly stabilized shorelines provide significantly lower habitat values (Tonnes 2008, Holsman and Willing 2007, Sobocinsk 2003, Brennan 2007, MacDonald 1994).

Question 2: Shallow Water Habitat, Accessibility and Presence, applies to Upper Shore Zone, Lower Shore Zone, and Deeper Zone

Structures covering up nearshore habitat have a strong negative impact on juvenile salmon PCEs. Shallow water habitat that is not available for any access, migration, or primary production, because it is covered up by structures like pilings, bulkheads, and jetties provide zero habitat. Habitat shaded by OWS provides reduced habitat value compared to undisturbed shallow water by inhibiting migration and SAV growth; see below “Shade Impacts”.

Question 3: Beach Logs, applies to Upper Shore Zone

Ecological functions of large wood on beaches include dissipation of wave energy, shoreline protection from erosion, sediment trapping, creation of temperature moderating microhabitats, and habitat for infauna (Simenstad et al., 2003), Tonnes 2008). These functions help create and maintain productive habitat for marine species, including juvenile PS Chinook salmon and HC summer-run chum salmon. Large wood and associated deposits of decaying marine vegetation on beaches are believed to also play important roles in prey production for juvenile salmon (Brennan et al. 2004).

The stabilizing function of large woody material on PS beaches likely contributes to better conditions for forage fish spawning habitats due primarily to its role in stabilizing appropriately sized spawning sediments. Large wood can also reduce beach erosion from waves by trapping beach sediment (DOE 2011) (Fresh et al., 2011) and can provide erosion control functions by reestablishing the storm berm, or backshore, thereby increasing absorption of wave energy and protecting structure of the upper beach (PSNERP 2009).

Question 4: Substrate Value, applies to Upper and Lower Shore Zone

Substrate of shorelines is driven to a large extent by site-specific geomorphology. Shorelines can be rocky, they can be steep or shallow, they can be bluffs or beaches, they can be composed of soft silt or large cobbles (Shipman 2008), and each of these shore types drive the use and value of the habitat for juvenile PS Chinook and HC summer-run chum salmon.

Feeder bluffs, rivers, and sediment ‘sinks’ (e.g. cuspate spits) recruit sediment to the nearshore which flows in predictable directions within shoreline “drift cells” (Shipman 2008). These sources and sinks are affected by shoreline disturbance via a variety of shoreline projects such as bulkheads, piers and floats, vegetation removal and others (Brennan 2007, Shipman 2009, Toft 2007, Toft 2009). For example, when waves reflect off shoreline armoring structures, particularly concrete bulkheads, they can erode sediments, and lead to beach ‘hardening’ and coarsening of substrate (Shipman 2009, Sobocinski 2003). Such outcomes permanently impair the ability of the habitat in such locations to support forage fish spawning, resulting in adverse, indirect effects to PS Chinook and HC summer-run chum salmon.

Important substrate categories in PS used in this NHV model are mud or mixed fines, sand or larger grained gravels, rocky and unnaturally compacted, each of which provide substantially different habitats for juvenile Chinook salmon HC summer-run salmon, forage species, and vegetation (Simenstad 1993, Pentilla 2003).

Question 5: Aquatic Vegetation Value, applies to Upper Shore Zone

Upper intertidal zone productivity is tied to saltmarsh, algal, and bacterial production (Odum, 1980), Thom 1984, Vernberg 1993, Rumrill and Sowers 2008). Organic matter is exported from the vegetation to nearshore and offshore waters (Odum 1980). The plant, algae, and bacteria communities provide, similarly to riparian vegetation, an essential pathway for the input of dissolved nutrients, organic matter, and invertebrates to the nearshore marine ecosystem (Rumrill and Sowers 2008). The higher the organic input from any of these three producers, the higher is the food availability for consumers including juvenile salmon.

Question 6: Water Quality Value, applies to Upper Shore Zone, Lower Shore Zone, and Deeper Shore Zone

Juvenile salmonids require optimal water quality conditions to support growth and maturation which include: optimal dissolved oxygen levels; minimal sediment and turbidity levels and free of contaminants. Water quality is a function of several variables, which are influenced by the intensity of shoreline development. Nearshore marine water quality is influenced by the level of contaminant inputs from, including but not limited to storm water, waste water treatment plant effluent, residential septic inputs, marina and ferry activities, and chronic super fund cleanup. Exposure to low DO levels and exposure to contaminants can affect the ability of juvenile salmonids to forage, avoid predation, reproductive success and migrate successfully (Servizi and Martens 1991, Newcombe and Jensen 1996, Jobling 1998, Hansen 1999, Baldwin 2003, Hecht 2007).

This model uses a surrogate approach to quantitatively evaluate water quality. In the absence of detailed water quality information, biologists use the surrounding habitat conditions listed above to determine which of the three simplified ratings, poor, medium, or excellent is appropriate.

2.4.3 Lower Shore Zone Habitat Indicator Questions

Question 1: Aquatic Vegetation Value

Shaffer (2003) found that juvenile salmon and surf smelt densities were significantly higher in kelp beds than in unvegetated habitat. An explanation for this habitat selection may be that habitat diversity is high in kelp beds and associated with enhanced prey resources and refuge from predators (Shaffer 2003). Fletcher et al. (2013) evaluated the differential use of nearshore habitat types in HC. They sampled for juvenile salmonids in five different habitat types: 1) natal river deltas and associated emergent marshes; 2) non-natal spit beach/emergent marsh pocket estuaries; 3) eelgrass; 4) rocky/cobble shorelines; and 5) mud/sand tideflats. They found highest chum (fall and summer-run) in eelgrass habitats and natal river deltas. The importance of eelgrass for the overall PS nearshore ecosystem has been described by many researchers (Phillips and Watson 1984; Mumford 2007). The particular importance of eelgrass for rearing Chinook in Willapa Bay is documented by a model developed by Semmens (2008).

Outside of PS, this behavior, fish selecting habitats with submerged aquatic vegetation, also has been shown. Lazzari et al (2006) found along the coast of Main, that the presence of most fish species was positively associated with Zostera, Laminaria, and to a lesser extent, Phyllophora. (Murphy et al., 2000) compared fish assemblages between three different subtidal habitat types in Alaska and found more species at sites with either eelgarass or kelp than at sites with filamentous algae. Murphy et al. (2000) found pink, chum, and coho salmon smolts at similar densities at eelgrass, kelp (short (< 1 meter)), and filamentous algae sites. However, chum salmon were more abundant in eelgrass habitat early in their migration. Johnson et al. (2010) sampled three different nearshore habitats in Prince Williams Sound, AK. They found greatest species richness in eelgrass (34) and kelp (33) compared to bedrock (22) habitats, which correlates with the cover provided. The cover provided by vegetation was greatest in eelgrass and least in bedrock.

Overall, it has been shown that juvenile salmon preferentially select eelgrass (Johnson et al. 2010, Fletcher et al. 2013) and kelp (Shaffer 2003, Johnson et al. 2010) and for chum early in their migration (Murphy et al. 2010). All these studies show a correlation between salmon abundance and cover density. The preferentially selected eelgrass and kelp habitats provided more cover and vegetative biomass than the habitats (filamentous green algae, non-vegetated habitat) with less salmonid abundance. NMFS uses these studies that show a preference of juvenile salmon for some macroalgae that provide lots of structure to formulate a working hypothesis for the NHV model. The assumption underlying the quantification of SAV value in the NHV model is that the more structure native aquatic macrophytes provide the higher is its value to juvenile Chinook and HC summer-run chum.

The last step in the NHV model in evaluating the habitat quality of SAV is the application of an OWS shading related reduction factor. As shading reduces the primary production of SAV, the number of points awarded for SAV is reduced proportionally to the shading, see next section.

2.4.4 Shade Impacts, applies to Upper Shore Zone, Lower Shore Zone, and Deeper Zone

Residential floats, associated boats, and to a lesser extent elevated and grated piers and ramps cause a reduction in underwater ambient light. This reduction affects salmon in several different ways. First, it alters their migration path and schooling behavior (Toft et al., 2007) which can be linked to increased predation (Willette 2001). Second, it reduces their cover and food source via reducing the light for growth of macroalgae including eelgrass (Burdick and Short, 1999; Shafer, 2002, Fresh et al., 2006) and in addition, boat use can result in prop scour, chopping up vegetation (Dunton and Schonberg, 2002). Third, OWS have been shown to provide habitat for predators in freshwater (Carrasquero, 2001) and the same applies to the marine nearshore. The additional habitat that OWS provide for predators and the additional migratory path length from swimming around OWS (Anderson et al. 2005) both likely result in increased predation on juvenile salmon.

There is substantial evidence that juvenile fish are less abundant in shallow water areas that are shaded by OWS compared to similar habitat without OWS. Able et al. (1998) report that fish abundance and species richness were lower under large piers in the Hudson River estuary compared to open water habitats. Munsch et al. (2014) found that in PS fish abundance and feeding, in particular for juvenile salmon, was reduced under piers. Several other publications also document that in PS juvenile salmon avoid shaded areas under OWS. Heiser and Finn (1970) documented reluctance of 35 millimeter to 45 millimeter juvenile chum and pink to pass under docks in PS: "...juvenile pink and chum are reluctant to leave the apparent safety of the shoreline areas and venture out along the bulkheads or breakwaters at the marinas when they are 35mm to 45mm in length. …fingerlings would move into deeper waters when confronted with a larger pier…." More recent studies have confirmed that observation. Simenstad (1999) found most juvenile salmonids away from the edge of the overwater structure or at the edge, and only one school underneath a structure. The authors conclude that this supports the premise that juvenile salmon avoid OWS because they physically block normal movement patterns and/or decrease light levels. Toft et al. (2007) reported that juvenile salmonid densities were higher at the edge of OWS than at other habitat types. Again, the author concludes that the OWS are impeding the movement of juvenile salmon, and that the fish are schooling at the edges of the structures. He found similar scenarios at other sites (personal communication, Toft 2010). As reported in Southard et al. (2006), the authors snorkeled underneath ferry terminals and found that juvenile salmon moved underneath terminals at low tides when there was more light penetrating the edges, and were not underneath the terminals at high tides when the water was closer to the structure and there was more shading. Ono (2010) investigated the impact of a large over-water structure on juvenile salmon migration behavior in shallow nearshore waters and found that juvenile salmon, including Chinook salmon, avoided and moved at distance from shading, staying on the bright side of the shadow edge. Ono (2010) reported that juvenile salmon generally stayed two to five meters away from the dock, even when the shadow line moved underneath the dock. These findings confirm that large overwater-structures disrupt juvenile migration.

Williams et al. (2003) is the only publication NMFS could find that documents different findings as to the behavior of juvenile salmon around OWS. Williams et al. (2003) report that pink and chum fry in PS were observed both outside the terminal and underneath the terminal at all times, and shadows produced by the 10-meter wide terminal did not appear to act as a barrier to fry movement. However, they sampled too early in the year to include PS Chinook salmon fry.

Most of the PS studies discussed above examined larger OWS, like apartment complexes and ferry terminals. Munsch et al. (2014) is currently the only PS study examining the effects of smaller OWS attached to bulkheads and their results support extrapolating from the studies of larger OWS to smaller. Thus, NMFS assumes that for all OWS including residential pier, ramp, and floats and boats, juvenile salmon avoid to some degree the shaded areas under structures and school at their edge.

Reduced salmonid use indicates that though some biological mechanism, potentially reduced visibility, reduced feeding success, and/or increased predation risk, the habitat quality of the area under and around the OWS is reduced. In the NHVs model we captured this reduction of habitat quality by applying an OWS shading related reduction factor to the points awarded for the accessibility and presence of “Shallow Water Habitat”.

An implication of juvenile salmon avoiding OWS is that some of them will swim around the structure (Nightingale and Simenstad 2001). That will cause them to utilize deeper habitat. Many biologists assume that early/small Chinook salmon smolts and early outmigrating fry utilize the shallow nearshore to avoid predation by piscivorous predators, including the ubiquitous staghorn sculpin and larger salmon. Willette (2001) reports findings that support this theory. Willette (2001) found that juvenile pink salmon in Prince William Sound leave the shallow nearshore when the biomass of large copepods, their food, declined. With the juvenile pink salmon foraging in deeper water, the mean daily individual predator consumption of salmon increased by a factor of five. In the absence of conclusive studies on the increase of predation risk on juvenile Chinook salmon associated with OWS in PS, the results from the Willette (2001) study leads NMFS to believe that an increase of predation on juvenile Chinook salmon as a result of modified migration and schooling behavior (e.g. swimming around OWS) is likely.

Further, NMFS considers it likely that OWS lead to increased predation in marine waters through aggregation of piscivorous predators under OWS (Williams et al. 2003). Overwater structures provide some of the physical habitat characteristics, like structure and hard attachment, which piscivorous predators including rockfish and sculpins prefer. Ratte and Salo (1985) did not find an increased number of predators at Sitcum Waterway Slip and Pierce County Terminal, both in PS. Similarly, Williams et al. (2003) did not find increased numbers of piscivorous predators at the Mukilteo ferry terminal. Both studies provide valuable empirical evidence as to the lack of accumulation of piscivorous predators at OWS. However, the limited duration and spatial extent of the studies does not allow broad generalizations that piscivorous predators do not accumulate under OWS for PS.

Different from the sparsely studied marine areas, several studies document that freshwater OWS are likely to result in an increase in predation. The reasons/mechanisms for this increased predation in freshwater include favorable microhabitat for piscivorous predators, decreased light condition that favor piscivorous predators, and increased migration length from swimming around OWS. Carrasquero (2001) indicated that northern pikeminnow are important salmonid predators in Columbia River reservoirs because of their preference for low-velocity microhabitats which are created by in-water structures. Petersen and Gadomski (1994) found that in laboratory experiments, the rate of predation by northern pikeminnow on subyearling Chinook salmon was inversely related to light intensity. About five times more salmon were eaten in the darker setting than in the lighter. Further, Anderson et al.'s (2005) predator-prey interaction model shows that the survival of juvenile spring Chinook salmon migrating through the Snake River depends more on travel distance than travel time or migration velocity. The NMFS assumes that at least two of these mechanisms, increased mortality from an increase in migration path length resulting from swimming around an overwater structure and from reduced light levels, are likely to apply for saltwater as well as for freshwater.

2.4.5 Prop Scour/Boat Scarring

Boat traffic in shallow water can cause increased turbidity and mechanical disturbance of SAV. Increased turbidity from suspension of sediment reduces light availability. The magnitude of reduced light availability depends on several parameters including the type of vessel, local substrate and currents. Mechanical disturbance of the plant tissue can result from drag and tear associated with direct disturbance by propellers or strong currents created by the propeller. Several researchers around the world have started to investigate and document the negative effects of recreational boating on SAV. Eriksson et al. (2004) found that recreational boating in inlets of the Baltic Sea appear to have a significant effect on SAV. The SAV in inlets used as marinas had declines in species richness and percentage cover that were not present in reference inlets. The water depth at which recreational boat traffic is likely to cause negative effects on SAV varies dependent on the type of vessel, height and length of the SAV and substrate. Hermann Gucinski (1982) researched the reduction in SAV productivity as a result of small vessel induced turbidity in Chesapeake Bay. He found the depth to which boating effected sediment resuspension was limited to below 2 meters (6 feet). Prop scouring in association with residential docks was also demonstrated by Burdick and Short (1999) and Shafer (1999). Prop wash, scouring, and the associated increase in turbidity have been noted in studies of large ferry terminals (Thom et al. 1996).

To estimate the depth to which boating affects eelgrass in PS, B. Burkle, WDFW, applied an experimental approach conducted an experiment (Appendix 3). He found that a12-foot Smoker craft with a 10 horsepower outboard motor dug up an eelgrass bed in less than 2 feet of water. It tangled fronds of eelgrass and cut them off in up to just over 3 feet of water, but at 4 feet, the motor did not affect eelgrass. The results of this experiment are in the range that other researchers have reported. Yousef (1974) observed visible increases in turbidity in areas less than 5 feet deep when running a 10-horsepower engine boat across a lake. In the marine areas of Florida, Zieman (1976) found that propeller scarring tends to occur in areas less than 1 meter deep. Sargent et al. (1995) report that areas of seagrasses in water depths greater than 6 feet are unlikely to be scarred. As a result, NMFS considers boat scarring and reduced primary production from increased turbidity likely if the proposed structure and moored boat are within 4 feet vertically of the top of the vegetation or in the absence of SAV to the sediment.

2.4.6 Crediting and Discounting Factors

In the PS NHV-HEA model we apply three crediting and discounting factors of 1.5 in the final, HEA worksheets for each of the four zones (RZ, USZ, LSZ, DZ), see "DSAY calc" worksheets or Appendix 1.

Credit Factor/Discount Factor 1: Does the affected area have documented or potential Pacific Herring or Forage Fish Spawning Habitat?

Areas that support forage fish, Pacific herring (*Clupea pallasi*), sand lance and surf smelt, provide especially important function to salmon as they support their food. This HEA crediting factor of 1.5 accounts for the additional habitat benefit of areas that grow food for Chinook.

Pacific herring spawn in only a few geographically disjunct areas. Pacific herring are dependent on certain species of sub-aquatic vegetation, such as eelgrass and, where eelgrass is not predominant, mud—bottom dwelling macro algae, such as *Gracilariopsis sp*. and *Ulva sp*., varying widely in tidal elevation, from subtidal depths to up near the ordinary high waterline (Pentilla 2007).

Surf smelt (*Hypomesus pretiosus*) and Pacific sand lance (*Ammodytes hexapterus)* each have particular habitat requirements for spawning; sand lance prefer relatively fine grain sands; surf smelt a combination of fine grain sand and courser gravel (Pentilla 2007). Surf smelt spawn occurs between +7.0 feet MLLW and MHHW and sand lance, +5.0 feet MLLW to MHHW. Both species have been documented to spawn on 10 percent of PS's shorelines, a fraction of the apparently appropriate habitat area within PS. However, because of the lack of knowledge around forage fish spawning extent and variability, NMFS considers undocumented upper beach substrate of appropriate grain size as suitable spawning habitat.

Credit Factor/Discount Factor 2: Is the affected area a pocket estuary, bluff backed beach, or pocket beach?

Beamer (2007) and Beamer et al. (2012) document that pocket estuaries[12] in the Skagit River delta and Whidbey basin consistently have significantly higher juvenile Chinook salmon densities than adjacent nearshore habitats. These studies, (Beamer 2007, Beamer et al. 2012), led scientist to believe that PS wide pocket estuaries close to natal rivers provide important early rearing habitat for juvenile Chinook (Fresh et al., 2011).

Beamer and Fresh (2012) sampled nearshore habitats in the San Juan Islands and found that bluff backed beaches[13] and pocket beaches[14] had significantly higher juvenile Chinook salmon densities than pocket estuaries, rocky shorelines, and barrier beaches. That pocket estuaries did not show high abundances of juvenile salmon can be explained with the distance to natal estuaries. There are no natal Chinook salmon streams on the San Juan Islands.

Bluff backed beaches provide the sediment supply for many PS drift cells (Shipman 2008, Simenstad et al. 2011). Their sediment input is essential to the maintenance of forage fish spawning beaches. Thus, regardless of whether bluff backed beaches in areas outside of the San Juan Islands are used preferentially by migrating salmon, too, they provide critical functions in supporting the food supply for Chinook salmons. NMFS based its decision to credit their value in PS HEA assessments on this critical support for an important food, sandlance and surf smelt.

In the absence of site-specific information showing that a pocket estuary or pocket beach does not provide higher value habitat than other nearshore habitat types, NMFS extrapolates from the above mentioned studies and errs on the side of the species. The NHV model & PS HEA assessments assume that these geomorphic conditions provide the basis for providing rearing habitat of higher value than other nearshore habitat types. The crediting factor accounts for the high habitat value of pocket estuaries, bluff backed beaches and pocket beaches to juvenile Chinook life histories in PS as demonstrated by Beamer (2007), Fresh et al. (2011), and Beamer et al. (2012).

Credit Factor/Discount Factor 3: Is the affected area within 5 miles of a major estuary?

The estuary and natal delta area is important for juvenile Chinook and HC summer-run chum to transition from delta to marine nearshore habitat (Simenstad et al. 1982). This brackish and protected area is important for juveniles to change physiologically from fresh to salt water and forage to increase in size prior to entering the marine environment. Redman et al. (2005) define the size of the area close

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[12] Pocket estuaries are partially enclosed bodies of marine water that are connected to a larger estuary (such as Puget Sound) at least part of the time, and are diluted by freshwater from the land at least part of the year (Beamer, 2007).

[13] Bluff backed beaches are erosional depositional beaches at the base of sediment bluffs.

[14] Pocket beaches are a particular variation of a beach that can look like ‘bluff-backed beach’ at the base of rocky bluffs. Unlike bluff-backed beaches, however, pocket beaches have no adjacent sediment source from drift cells and thus are not part of drift cell systems. Beach sediments in pocket beaches are derived locally (Beamer and Fresh 2012).

to the natal delta to include all areas within five miles of the natal delta. The definition in Redman et al. (2005) informed the areal extend used for applying the crediting factor for the PS NHV-HEA model.

2.5. Project Example Application

In this section we present you with an example. Using the NHV and HEA model as described above, you can follow along determining the habitat loss in DSAYs from a standard PRF. Enter the project information from the example below in the PS NHV – HEA Excel spreadsheets and compare your results to the summary table below, Table 1. Further, Appendix 1 displays the "summary" and "DSAY calc-LSZ" Excel worksheets for this example.

Example Pier Ramp and Float Project Description:

- Location: Hale Passage (not within 5 miles of major estuary, not at bluff-backed beach)
- WQ: before optimal, after medium
- Riparian Zone: 800 square feet of new woody vegetation to be planted immediately behind bulkhead where there was previously lawn. To be planted the spring or fall following construction. Vegetation will be recorded in deed and is assumed to remain on site in perpetuity (300 years).
- New 150-foot long pier, ramp and float structure.
- Distance from existing bulkhead to the +5 MLLW line (dividing elevation between USZ and LSZ) 60 feet.
- USZ 4 8-inch steel piles support 4-foot by 80-foot aluminum pier with 89 percent functional grating, 60 percent open space.
- Project elements in USZ located within potential surf smelt and sand lance spawning habitat.
- Vegetation in USZ 10% *Gracilaria sp*.
- Substrate is mix of sand and gravel. Surf smelt generally spawn at elevations higher than + 7 feet MLLW and sand lance at elevations higher than + 5 feet MLLW tidal elevation.
- In LSZ six 8-inch steel piles for pier and float support.
- An 8-foot by 30-foot float at the end of the ramp will have 50 percent functional grating with 60 percent open area. Elevations at the float range from zero to minus 2 feet MLLW. There would be prop scour if boat was moored at float rather than mooring buoy.
- 8-foot by 20-foot watercraft with 2-foot draft moored at mooring buoy in DZ.
- *Ulva sp.* coverage exceeding 25 percent underneath, immediately adjacent, and for 25+ feet waterward of the proposed float location. There is documented herring spawning on site.

Figure 2, below, depicts this example.

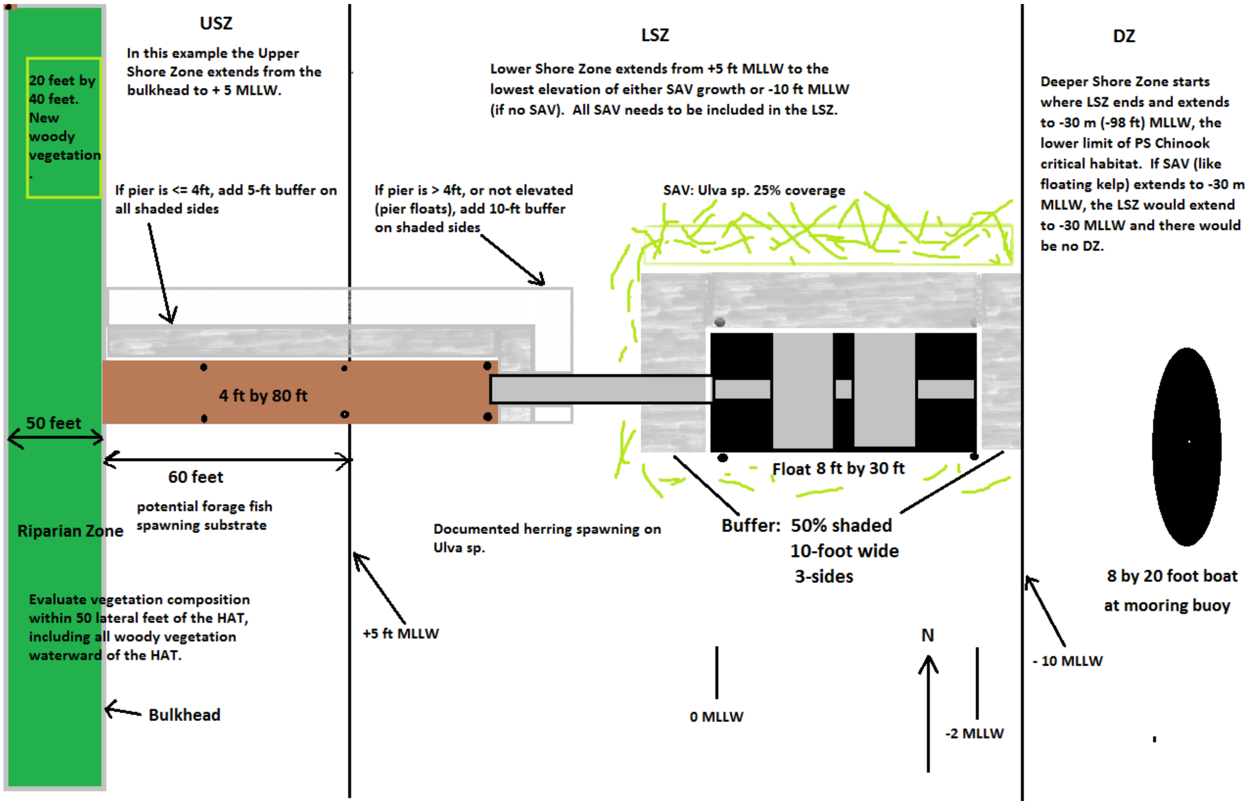

Figure 2: Example Pier Ramp and Float

Table 1: Summary of DSAY values for PRF Example

Habitat Values Results	Before	After	Area	Delta	DSAYs
Riparian Zone	0.050	0.275	0.0184	0.2250	0.146
Upper Shore Zone	0.544	0.480	0.0193	-0.0635	-0.0612
Lower Shore Zone	0.700	0.481	0.0207	-0.2195	-0.2275
Deep Zone of CH	0.300	0.166	0.0037	-0.1339	-0.0167
Sum					-0.1591

__Filling in the RZ worksheet:__

Enter the 800 sqft of lawn in E13 (before) and in G11 (after). Enter a 1 in D27 to reflect the 1 year delay between impact and mitigation.

Filling in the DSAYs RZ worksheet:

Check that F15 reflects that vegetation will remain in perpetuity. Entry should read 300.
Enter a “y” in E23 to reflect the potential forage fish spawning habitat.
All other parameters will be copied over from “RZ” worksheet.

Filling in the USZ worksheet:

The Affected Area in the USZ is 60 ft long and 14 ft wide (4 ft for pier plus 5 feet buffer on either side). Enter this information in cell C6 and C7.

1. Shoreline Conditions input is a “0” for before and after conditions as the site if fully bulkheaded.

2. Shallow Water habitat, Accessibility and Presence; (what shallow water area [in square feet] is lost to juvenile rearing?) would be 0 for before (cell E14). The program uses this input to assign the maximum “project points” for the un-impacted habitat parameter, a four (cell F16). The model provides an “Area Calculation Template for Pilings” embedded in the Shade Imp USZ worksheet to aid in determining what area is taken up by pilings. For this example impact from pilings is relevant for the “after project” site conditions. In the Shade Imp USZ enter the number of pilings, four, for after conditions (cell C25) and diameter, 0.8 ft, (cell C26). The area for after conditions is calculated in cell C27 and automatically copied to the USZ worksheet into cell H14 (after).

3. Habitat Function from Large Wood would receive the same input for before and after conditions as there is no change from the proposed action. A 0 would be appropriate as no wood is mentioned in the project description.

4. Substrate Size would receive a “Y” in E21 (before) and H21 (after) as the project description states “sand and gravel”.

4d. Habitat Loss from Development would receive a “0” in E23 (before) and a 2.01 in I23 (after) reflecting the area taken up by the 4 pilings.

4e. Habitat Degradation would receive the same number for before and after. This could be a “0” or small percentage reflecting potential sediment coarsening related to the bulkhead. As long as the before and after values are the same this input will not change the overall NHV for the USZ.

5. Vegetation Condition would receive a “Y” in E28 (before) and H28 (after) as the project description states 10 percent *Gracilaria sp.*

6. Water Quality Condition; A new PRF generally reduces water quality by one category. So E31 (before) would receive a “Y” and H32 (after) would receive a “Y” with all other input/yellow cells for this habitat indicator keeping a “N”. The important consideration for this category is to reflect the water quality change. This could be either from an optimal to a medium or a medium to a poor.

After the user fills out yellow coded “site conditions” for a habitat parameter, the program sums all resulting light green coded “project points” to yield total Summary Project Point by Habitat Indicator (row G (before) and J (after), dark green). The model sums all six Summary Project Point by Habitat Indicator as Site Points Before (cell G34) and after (cell J34). To get the NHV which needs to be between 0 and 1, the Site Points get divided by the maximum possible points.

Filling in the Shade Imp USZ worksheet:

Only entry aside from using the “Area Calculation Template for Pilings” is the pier in F6, 240 sqft (4*60=240).

Pier is fully grated, 4-ft wide, and elevated, thus no buffer required.

Four pier supporting pilings in USZ should already have been entered as discussed above.

Filling in the Shade Imp LSZ worksheet:

For the after condition fill in the dimensions of structure and buffers: Enter “240” inF9 for float area (8*30) and “660” in F11 for 10-foot side buffer on three shade receiving sides including corners (10*50+2*10*8=660). The percent shading impact of the buffer is always half of the highest shading structure; a “0.5” if a boat is moored at the float and a “0.35” (half of the standard 0.7 float shading) if no boat is moored.

Enter the six 0.8 diameter pilings in the “Area Calculation Template for Pilings” at the bottom of the Shade Imp LSZ worksheet

Filling in the LSZ worksheet:

The SAV condition is the same for before and after, unless a proposed action would actively remove SAV. The likely reduction in SAV growth and primary production is captured through the shading, E15 (before) and H15 (after). H15 should read 0.6, reflecting the shading from the float. Enter a “Y” in E12 (before) and H12 (after) as there is potential herring spawning on site. For areas with potential herring spawning the lowest possible vegetation category is medium low which results in 2 point for this category.

Filling out the remainder of the worksheet follows the logic and instructions detailed for the USZ.

Filling in the Shade Imp DZ worksheet:

For the after condition enter the area of the boat in F10 (8*20). The percent shading impact should be entered in H10 as “1” for 100 percent shading. As the boat will be on a buoy and move around, no buffer is added.

Filling in the DZ worksheet:

1. Water Habitat, Accessibility and Presence. Record a 0 for before and after as there are no pilings or other three dimensional structures proposed.

3. Water quality. Record a one point reduction in WQ.

DSAY calc-USZ and DSAY calc-LSC worksheets:

Enter a “y” for the “Crediting or Discounting factors” forage fish and herring spawning habitat in E23.

Appendix 1: Nearshore Habitat Model and HEA "Summary" Worksheet and "DSAY calc-LSZ" Worksheet

Summary Worksheet

Summary of Parameters Needed for HEA

Red cells are transferred from other worksheets.

Nearshore Habitat Values Results	Before	After	Area	Delta	
Riparian	0.0500	0.2750	0.0184	0.2250	
Upper Shore Zone PRF	0.5438	0.4802	0.0193	-0.0635	
Lower Shore Zone PRF	0.7000	0.4805	0.0207	-0.2195	
Deeper Zone	0.3000	0.1661	0.0037	-0.1355	
	Values transferred from previous worksheets.			Improvements: delta > 0	
				Function Loss: delta < 0	

HEA Results	Years project exists	DSAYs	
Riparian	300	0.1463	Values transferred from "DSAY calc" worksheets.
Upper SZ	300	-0.0612	
Lower SZ	300	-0.2275	
Deeper Zone	300	-0.0166	
Sum		-0.1590	

DSAY calc-LSZ Worksheet, Example

The purple cells are filled in automatically from the NHV sheets "summary".

Yellow cells are for user to fill in.

To use model, only enter values in highlighted areas.

Initial Value of Habitat:	0.7
Years to a Fully Functioning Habitat:	1
Base Year:	0
Discount Rate	0.03

# Years Project Exists:			300
Value of Post-Construction Habitat:			0.4805031
Delta Habitat Values			-0.219497
Acres of Habitat:	See Area Calculation Sheet		0.020731
		Enter Y/N	
Crediting or Discounting Factors	Is there potential herring spawning on-site?	y	1.5
	Is affected area in a pocket estuary, bluff backed beach, or pocket beach?	n	1
	Is affected area within 5 miles of an estuary of a Chinook or HC summer chum bearing stream?	n	1

TOTAL DSAYs:	**-0.227**

Appendix 2: Sensitivity Testing

Needs to be updated with using PS NHV-HEA.xls

The table below lists five different sets of nearshore example projects. Between the different versions within each set of examples, only one parameter is changed. This allows for evaluating the influence of changes in this one parameter on the DSAYs. Further, the table allows for comparisons of impacts in DSAYs between the different examples. The goal of this sensitivity analysis is to check the results, the amount of habitat gain or loss, for each scenario against professional judgment and experience. These examples aid in a final check whether the NHV model is sufficiently complete and biologists agree with the quantification of the underlying assumptions.

Project Descriptions:

1. Bulkhead (BH): Installation of BH in front of existing BH; 100 ft long, 10 ft deep, filling 1000 sqft of USZ; 0 pts for existing: WQ, vegetation, shoreline, beach logs; Years Project exists: 300
2. Effect of shading in Upper Shore Zone (USZ): Marina builds 10 X100 ft solid deck out over nearshore from existing bulkhead. Elevations in front of bulkhead range between +4 and +6 MLLW. Treat entire area as USZ, since it is adjacent to BH. Habitat Reduction for Sediment: 25 percent before and after since BH remains unchanged. 0 pts for existing: WQ, vegetation, shoreline, beach logs; Years Project exists: 300
3. Planting riparian vegetation, directly behind concrete BH, where there used to be lawn; 10 ft by 100 ft: 1000 sqft. 3a trees, 3b shrubs.
4. Installation of new single-use float 8X30 ft, 6 10-inch piles in LSZ, and 1 boat 20X8, 50 percent grading, sediment >25 percent sand or larger grained, point 1. No prop scour scenario; aquatic vegetation score differs between scenarios, see below. No forage fish or estuary credit.
    a. Aquatic vegetation score 4
    b. Aquatic vegetation score 3
    c. Aquatic vegetation score 2
    d. Aquatic vegetation score 1

   The assumed duration the project exists is 300 years for a pier ramp and float. Entered in "DSAY calc-lower" tab.
5. Removal of 500 sqft debris (concrete rubble) from LSZ. Sediment >25 percent sand or larger grained, point 1. Aquatic vegetation value very low, 1 point. WQ 0.5 points. Difference between scenario a and b is debris removal from under 50 percent graded 8X30 float supported by 4 pilings (a) vs. unshaded area (b).
6. Impact in USZ from fully grated pier is impact from piles only.

Project types covered:

Installation and removal of: Pier Ramp and Float, other OWS, boat ramps, piles and dolphins, bank protection/armoring, riparian vegetation.

Effects of: prop scour, other sediment disturbing activities like cables and anchors dragging on sediment from buoys.

Dredging – needs more development

Project types not covered:

Fish passage blockage removal.

Effects on species other than juvenile PS Chinook.

Number	Difference within project category	Affected Area [sqft]	Parameter	Points Before	Points After	HNV befor after
1a	<u>Installation of BH</u> in front of existing BH: Affected area considered in 1b is 3 times the size as in 1a. This shows that the DSAYs will be the same, regardless over which affected area the impact is considered.	<u>1000 sqft</u>	Sediment	3	0	.438
			Area Impacted by High Structure	4	0	0
1b		100*20 <u>=2000 sqft</u> Account for effect on sed.	Sediment	3	**1.5**	.438
			Habitat Reduction	0 percent	0 percent	.219
			Area Impacted by High Structure	4	**2**	
1c	For this scenario, a 20 percent reduction of sediment quality is added to the 1b scenario.	100*20 =2000 Account for effect on sed.	Sediment	3	1.2	.438
			Habitat Reduction	0 percent	**20 percent**	.200
			Area Impacted by High Structure	4	2	
2a	Effect of shading in USZ: Marina builds 10 X100 ft solid deck out over nearshore from existing bulkhead 0 pts: WQ, vegetation, shoreline, beach logs; 25 percent sediment habitat reduction	100* (10+10)= 2000 sqft	Sediment	2.25	0.73	0.391
			Habitat Reduction	25 percent	25 percent	0.195
			Discounting Factor proportional to shading for: Shallow Water HA, Substrate	1 1 substr.	0.6 0.33	

Number	Difference within project category	Affected Area [sqft]	Parameter	Points Before	Points After	HNV before after
2b	Project as 2a, baseline better: WQ: 2	100* (10+10)= 2000 sqft	Same as in 2a			.516 .319
3a	Planting 1000 sqft trees.	1000 sqft				.100 .275
3b	Planting 1000 sqft shrubs.	1000 sqft				.100 .225
4a	Installation of new single-use float 8X30 ft, 6 10-inch piles, and 1 boat 20X8, 50 percent grading, sediment >25 percent sand or larger grained, point 1, WQ med 0.5 points. No prop scour scenario; aquatic vegetation score 4.	= 240 + 160 + (30+30+8+10+10)* 10+3= 1283 sqft	Aquatic vegetation	4	1.84	0.929 0.575
			Discounting Factor proportional to shading for SAV & for Shallow Water HA	1	.46 .68	
4b	aquatic vegetation score 3	1283 sqft	Aquatic vegetation	3	1.38	0.786 0.508
			Sediment	1	1	
			Discounting Factor proportional to shading for SAV & for Shallow Water HA	1 1	.46 .68	
4bII	Installation of new single-use float 8X30 ft, 6 10-inch piles, 1 boat 20X8 at mooring buoy in DZ, 50 percent grading, sediment >25 percent sand or larger grained, point 1, WQ med 0.5 points. No prop scour	1283 sqft	LSZ: Aquatic vegetation DZ: Primary Product	2 1	1.54 0.1	LSZ 0.786 0.535
			LSZ: Sediment	1	1	DZ 0.833

Number	Difference within project category	Affected Area [sqft]	Parameter	Points Before	Points After	HNV befor after
	scenario; aquatic vegetation score 3.		LSZ: Discounting Factor proportional to shading for SAV & for Shallow Water HA	1 1	0.51 0.71	0.413
4c	aquatic vegetation score 2	1283 sqft	Aquatic vegetation	2	.92	0.643 0.443
			Sediment	1	1	
			Discounting Factor proportional to shading for SAV & for Shallow Water HA	1 1	.46 .68	
4cII	Installation of new single-use float 8X30 ft, 6 10-inch piles, 1 boat 20X8 at mooring buoy in DZ, 50 percent grading, sediment >25 percent sand or larger grained, point 1, WQ med 0.5 points. No prop scour scenario; aquatic vegetation score 2.	1283 sqft	LSZ: Aquatic vegetation DZ: Primary Product	2 1	1.03 0.1	LSZ 0.643 0.462
			LSZ: Sediment	1	1	DZ 0.883 0.548
			LSZ: Discounting Factor proportional to shading for SAV & for Shallow Water HA	1 1	0.51 0.71	
4d	aquatic vegetation score 1	1283 sqft	Aquatic vegetation	1	.46	0.50

Number	Difference within project category	Affected Area [sqft]	Parameter	Points Before	Points After	HNV befor after
						0.299
			Sediment	1	.46	
			Discounting Factor proportional to shading for SAV & for Shallow Water HA	1 1	.46 .68	
4dII	Like 4e except: Boat 20X8 at mooring buoy in DZ Aquatic vegetation score 1. DZ: WQ med 1 point	1283 sqft	LSZ: Aquatic vegetation DZ: Primary Product	1 1	0.51 0.1	LSZ 0.5 0.319
			LSZ: Sediment	1	0.51	DZ 0.833 0.548
			LSZ: Discounting Factor proportional to shading for SAV & for Shallow Water HA	1 1	0.51 0.71	
4e	aquatic vegetation score 0	1283 sqft	Aquatic vegetation	0	.46	0.357 0.234
			Sediment	1	.46	
			Discounting Factor proportional to shading for SAV & for Shallow Water HA	1 1	.46 .68	
4eII	Like 4e except:	1283 sqft	LSZ: Aquatic vegetation	0	0	LSZ

Number	Difference within project category	Affected Area [sqft]	Parameter	Points Before	Points After	HNV befor[e] after
	Boat 20X8 at mooring buoy in DZ		DZ: Primary Product	1	0.1	0.357 0.246
	Aquatic vegetation score0.		LSZ: Sediment	1	0.51	DZ 0.833
	DZ: WQ med 1 point		LSZ: Discounting Factor proportional to shading for SAV & for Shallow Water HA	1 1	0.51 0.71	0.548
5a	Removal of 500 sqft debris (concrete rubble) from LSZ from under existing float, scenario 4d.	1285 sqft	Aquatic vegetation	.46	.46	0.274 0.300
			Sediment	.28	.46	
			Discounting Factor for SAV and Sediment proportional to shading	.46	.46	
5b	Removal of 500 sqft debris (concrete rubble) from LSZ NOT under float.	1285 sqft entered in Shade Imp LSZ (before) cell B13	Aquatic vegetation	1	1	0.444 0.500
			Sediment	.61	1	
			Discounting Factor for SAV and Sediment proportional to shading	1	1	

5a&5b percentage of reduction of sediment value resulting from rubble is same. However, points for sediment are lower if it is covered by OWS/shaded. Assumption: vegetation value cannot exceed 1 (very low) for shaded areas.

2a&2b same project has slightly less impact if baseline values are better; WQ: 0 (for 2a) vs 2 (for 2b)

Appendix 3: Excerpt from a 2007 e-mail from Bob Burkle

Several years ago when the question of prop scour on eelgrass came up, I conducted a quick and dirty experiment on my own time to get an idea of the range of impacts possible. What I did was run the small boat I owned at the time (12 foot Smoker craft with a 10 horse outboard) in the eelgrass bed growing off the Lilliwaup River in HC to see what effect it had. I found that it dug up the bed and eelgrass along with it when running in less than 2 feet of water, that it tangled fronds of eelgrass and cut them off in up to 3 feet of water, or sometimes a little more in lush eelgrass and still water, but at 4 feet it did not affect eelgrass. This is a boat that, when tied up to a dock, could be launched in an inch or two of water, so I came to the conclusion that if the dock it was tied up to was located at least 4 vertical feet above adjacent eelgrass beds, I would not be able to impact them. I then consulted with a friend in the Department who owns a 21 foot big water deep V boat that draws 3 feet of water and had him run his boat over an eelgrass bed. It turns out that he hit eelgrass at 6 feet but not at 7. Again, this is a boat that when tied up to a dock would require at least 3 feet of water to launch or land, so again, if the dock was located 4 vertical feet above adjacent eelgrass it would not be impacted as the tide would have to be 7 feet above the eelgrass before he could launch or tie up. So therefore I came to the conclusion that if a dock was located 4 vertical feet above the adjacent bed no eelgrass would be harmed by boat access.

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Abbreviations and Acronyms

CH	Critical Habitat
DSAYs	Discounted Service Acre Years
DZ	Deeper CH Zone
ESA	Endangered Species Act
HC	Hood Canal
HEA	Habitat Equivalency Analysis
LSZ	Lower Shore Zone
LWM	Large Woody Material
MHHW	Mean Higher High Water
MLLW	Mean Lower Low Water
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NHV	Nearshore Habitat Values
OWS	overwater structures
PCE	Primary Constituent Elements
PS	Puget Sound
RZ	Riparian Zone
SAV	Submerged Aquatic Vegetation
USZ	Upper Shore Zone