UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
West Coast Region
1201 NE Lloyd Boulevard, Suite 1100
PORTLAND, OR 97232-1274

Refer to NMFS No:
WCRO-2015-00006

July 29, 2020

Michelle Walker
Department of the Army
Seattle District, Corps of Engineers
P.O. Box 3755
Seattle, Washington 98124-3755

Re: Endangered Species Act Section 7(a)(2) Biological Opinion and Management Act and Essential Fish Habitat Response for the Northwest Alloys, Inc., Dock 1 Repair Project, Longview, Washington

Dear Ms. Walker:

Thank you for your letter of June 14, 2017, requesting initiation of consultation with NOAA's National Marine Fisheries Service (NMFS) pursuant to section 7 of the Endangered Species Act of 1973 (ESA) (16 U.S.C. 1531 et seq.) for The Northwest Alloys, Inc. Dock 1 Repair Project. This consultation was conducted in accordance with the 2019 revised regulations that implement section 7 of the ESA (50 CFR 402, 84 FR 45016).

NMFS also reviewed the likely effects of the proposed action on essential fish habitat (EFH), pursuant to section 305(b) of the Magnuson-Stevens Fishery Conservation and Management Act (16 U.S.C. 1855(b)), and concluded that the action would adversely affect the EFH of Pacific Coast Salmon. Therefore, we have included the results of that review in Section 3 of this document.

In this opinion, we conclude that the proposed action is not likely to jeopardize the continued existence of Snake River (SR) fall Chinook salmon (*Oncorhynchus tshawytscha*), Lower Columbia River (LCR) Chinook salmon, Columbia River (CR) chum salmon (*O. keta*), or Upper Willamette River (UWR) Chinook salmon, or result in the destruction or adverse modification of their designated critical habitats. In section 2.12 of this document we concur with your conclusion that the proposed action is not likely to adversely affect Upper Columbia River (UCR) spring Chinook salmon, SR spring/summer Chinook salmon, LCR coho salmon (*O. kisutch*), LCR steelhead (*O. mykiss*), SR steelhead, UCR steelhead, Middle Columbia River (MCR) steelhead, UWR steelhead, SR sockeye salmon (*O. nerka*), green sturgeon (*Acipenser medirostris*), eulachon (*Thaleichtys pacificus*) or Southern Resident Killer Whales (*Orcinus orca*) or their designated critical habitat.

As required by section 7 of the ESA, we are providing an incidental take statement with the opinion. The incidental take statement describes reasonable and project measures we consider necessary or appropriate to minimize incidental take associated with this action. The take statement sets forth nondiscretionary terms and conditions, including reporting requirements that the Corps and any person who performs the action must comply with to carry out the reasonable

and prudent measures. Incidental take from actions that meet these terms and conditions will be exempt from the ESA take prohibition.

Please contact Tom Hausmann, in Portland, Oregon, at 503-231-2315 or Tom.Hausmann@noaa.gov if you have any questions concerning this section 7 consultation, or if you require additional information.

Sincerely,

Kim W. Kratz, Ph.D
Assistant Regional Administrator
Oregon Washington Coastal Office

cc: Danette Guy, USACE

Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response

Northwest Alloys, Inc. Dock 1 Repair Project

NMFS Consultation Number: WCRO-2015-00006

Action Agency: U.S. Army Corps of Engineers

Affected Species and NMFS' Determinations:

ESA-Listed Species	Status	Is Action Likely to Adversely Affect Species?	Is Action Likely To Jeopardize the Species?	Is Action Likely to Adversely Affect Critical Habitat?	Is Action Likely To Destroy or Adversely Modify Critical Habitat?
Lower Columbia River Chinook Salmon (*Oncorhynchu tshawytscha*)	Threatened	Yes	No	Yes	No
Snake River Fall Run Chinook Salmon (*O. tshawytscha*)	Threatened	Yes	No	Yes	No
Upper Willamette River fall Chinook Salmon (*O. tshawytscha)*	Threatened	Yes	No	Yes	No
Columbia River chum (*O. keta*)	Threatened	Yes	No	Yes	No
Upper Columbia River spring Chinook (O. *tshawytscha*)	Endangered	No	No	No	No
Snake River spring/summer Chinook *(O. tsawytscha*)	Threatened	No	No	No	No
Snake River steelhead (*O. mykiss*)	Threatened	No	No	No	No
Middle Columbia River steelhead (*O. mykiss*)	Threatened	No	No	No	No
Lower Columbia River steelhead (*O. mykiss*)	Threatened	No	No	No	No
Upper Columbia River steelhead (*O. mykiss*)	Threatened	No	No	No	No

dock include NWR 2011-4156 (removal of seven piles and dredge removal of 30,300 cubic yards of sediment), WCR 2014-1663 (contaminated sediment dredge cleanup), WCR 2015-3036 (pier maintenance), and WCR 2015-3476 (maintenance dredging).

The aquatic habitat of the Columbia River within the action area provides habitat for a variety of benthic, epibenthic, and water column organisms. The benthic topography is in a state of relatively constant change in the Columbia River estuary due to natural sediment transport processes. Substrate within both subtidal and intertidal benthic environments consists largely of silts and medium-to-coarse alluvial sands.

Anadromous fish are exposed to high rates of predation during all life stages. Fish, birds, and marine mammals, including harbor seals, sea lions, and killer whales all prey on juvenile and adult salmon in the action area. The Columbia River Basin has a diverse assemblage of native and introduced fish species, some of which prey on salmon, steelhead, and eulachon. The primary resident fish predators of salmonids in many areas of the Columbia River inhabited by anadromous salmon are northern pikeminnow (native), smallmouth bass (introduced), and walleye (introduced). Other predatory resident fish in the action area include channel catfish (introduced), Pacific lamprey (native), yellow perch (introduced), largemouth bass (introduced), and bull trout (native). Increased predation by non-native predators has and continues to decrease population abundance and productivity (NMFS, 2013b).

Avian predation is a factor limiting salmonid recovery in the Columbia River Basin. Throughout the basin, piscivorous birds congregate in the estuary near manmade islands and structures. Avian predation has been exacerbated by environmental changes associated with river developments. Water clarity caused by suspended sediments settling in impoundments increases the vulnerability of migrating smolts to avian predation. Dredge spoil islands, associated with maintaining the Columbia River navigation channel, provide habitat for nesting Caspian terns and other piscivorous birds. Caspian terns, double-crested cormorants, glaucous winged/western gull hybrids, California gulls, and ring-billed gulls are the principal avian predators in the basin. As with piscivorous predators, predation by birds has and continues to decrease population abundance and productivity (NMFS, 2013b).

Anadromous fish in the action area are also affected by water quality. Columbia River water quality is degraded by legacy hot spots and stormwater. Hot spots are usually associated with urban areas where sediment has been contaminated by recalcitrant, toxic organic compounds and metals that entering the river as industrial waste or spills, sequestered to the sediment and is slowly transported downstream and re-released to the water column. One example of legacy contamination are creosote treated piles that slowly re-release polycyclic aromatic hydrocarbons (PAH) to the water column. Stormwater becomes contaminated by organic and metals as it flows over impervious surfaces. These contaminants are to varying degrees removed by natural and engineered treatment processes before stormwater is discharged to the Columbia River but stormwater almost always transports some contaminants to the river. Although the concentrations of organic compounds and metals from hot spots and stormwater are dilute, there many stormwater outfalls and hot spots in the Lower Columbia River so that small migrating fish are likely to be exposed to several sources as they move downstream.

Salmon and steelhead reside in or migrate through the action area. The action area includes shallow water shoreline habitat. Subyearling LCR, SR, and UWR fall-run Chinook salmon migrate along the shoreline in shallow water. Most subyearling fall Chinook migrate through the action area in the late summer and early fall, before the in water work window. However, some subyearling Fall Chinook reach the estuary late in the year and may reside in the estuary over the winter to feed and grow before entering the ocean in the spring (NMFS, 2013b). Subyearling Fall Chinook are expected to be in the action area before, during and after the in water work window. Adult Fall Chinook salmon migrate past the action area from August through November, before and during the start of the in water work window but do not migrate in shallow water along the shoreline and travel rapidly upstream to their natal tributaries (NMFS, 2013b).

CR Chum fry migrate downstream almost immediately after emergence in April and May and spend the summer in the freshwater and upper estuarine zones of the estuary above the action area before migrating to the ocean (NMFS 2013). Juvenile chum salmon are not expected to be in the action area during the in water work window but will migrate past the action area at other times of the year. Returning adult chum salmon migrate past the action area from October through December, overlapping part of the in water work window. Adult chum are swimming rapidly past the action area to spawning sites in Lower Columbia River Gorge tributaries (NMFS, 2013b).

As described above in the Status of the Species and Critical Habitat sections, factors that limit the recovery of salmon and steelhead vary with the overall condition of aquatic habitats on private, state, and Federal lands. Within the action area, the riparian area has been degraded by the effects of land use resulting in degradation of estuarine rearing habitats, wetlands, and riparian areas, impeded fish passage, and the loss of habitat refugia.

2.5 Effects of the Action

Under the ESA, "effects of the action" are all consequences to listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action. A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action (see 50 CFR 402.17). In our analysis, which describes the effects of the proposed action, we considered 50 CFR 402.17(a) and (b).

The effects of the proposed action and related activities are: 1) Degrading habitat water quality with contaminated suspended sediment and sound pressure waves during pile driving (temporary construction effects), 2) Degrading shallow water habitat with predator habitat during the extended lifespan of the over-water structure (permanent structural effects), and 3) wake stranding from OGV traffic.

The proposed action is required because there are structural integrity concerns with the current structure. NWA intends to and expects to restore the structural integrity of the structure and thus meaningfully extend the life of the structure. The dock is over 50 years old and so we estimate that major structural repairs could extend its service life by up to 40 years.

As a result, the effects of the structure will now occur for longer into the future, affecting many additional cohorts of listed fish. These additional effects result from the structures being replaced or repaired, i.e., are caused by the proposed action, are thus properly construed as effects of the action. Because the structure was built in the late 1960s, the effects of the structure itself have never been consulted on under the ESA so the analysis is not duplicative of an existing effort.

Effects to Critical Habitat

Degrading water quality with suspended sediment and sound pressure waves during pile driving will impair features of rearing and migration habitat. Extending the presence of an obstruction in the shallow water habitat represents a prolonged hazard to safe passage in migration, and prolonged structure-associated habitat impacts in rearing habitat (e.g. shade).

Construction Effects.

Sediment and Toxic Compounds

Water quality for subyearling Chinook salmon smolts will be temporarily degraded by sediment associated with pile removal and installation. The vibratory removal of 90 piles and the vibratory installation of 70 new piles will create 160 suspended sediment plumes. Once in the water column, the Columbia River will transport and disperse suspended sediment will downstream. In an evaluation of turbidity generated by vibratory pile removal at Jimmycomelately Creek, suspended sediment concentrations from activation of the vibratory hammer to loosen the pile from the substrate ranged from 13 to 42 milligrams per liter and averaged 25 milligrams per liter. A 10- to 16- foot diameter plume extended at least 15 to 20 feet from the actual pulling event (Weston Solutions, 2006). We expect areas of turbidity and suspended sediment concentrations associated with the proposed action will be similar in scale for each of the 160 plumes.

The existing wooden piles were treated with creosote. Creosote is a wood preservative that contains a mixture of hydrophobic organic compounds. Some of these compounds are toxic to fish but are not bioavailable when they are sequestered in the creosote in the pile (Stratus Consulting, 2006). Over time, these compounds will slowly partition from the wooden piles to the organic carbon in the sediment surrounding the piles until they reach an equilibrium determined by the fraction of organic carbon in the sediment. When this surrounding sediment becomes suspended by pile driving, a very small fraction of these chemicals may undergo phase transfer to suspended or dissolved organic matter in the water column. Once the compounds are in suspended or dissolved organic matter in the water column they are more bioavailable to fish than they are when sequestered in the piles or in the sediment around the piles (Johnson et al., 2007b).

In principle, the action of the vibratory pile driver removing the piles increases the bioavailability of toxic compounds in creosote treated piles. However, since the mass of organic matter in the receiving medium (i.e. the water column) for each phase transfer is much less than the mass of organic carbon in the source (i.e. piles), the mass of transferred compound is many orders of magnitude lower than the mass in the source. Thus, the actual mass of compounds

transferred to the flowing water column is likely much too small to actually be acutely toxic to fish.

Sound Pressure

Impact pile driving also degrades the rearing and migration critical habitat PBF of water quality by generating sound pressure waves that have the potential to injure and kill fish. The 70 new 16 inch diameter piles installed by impact driving will require 750 strikes each to be proofed. NMFS estimates that the maximum worst-case sound pressure levels resulting from impact driving 16-inch diameter steel pilings will be 200 dBPeak (re: 1µPa), 191 dBRMS (re: 1µPa), and 174 dBSEL (re: 1µPa2·sec) 9 meters from the source (Laughlin, 2004). A bubble curtain will reduce underwater sound pressure wave energy (Longmuir and Lively, 2001; Reyff, 2003; Wursig et al., 2000) and the likelihood of fish injury (Keevin, 1998). However, the extent to which bubble curtains can lower sound pressure is highly variable (Oestman et al., 2009; Reyff, 2003; Rodkin and Reyff, 2007) and bubble curtains may not bring the sound pressure levels below biological thresholds for death or injuries of ESA-listed salmonids. Based on studies they reviewed, (Oestman et al., 2009) concluded that an air bubble curtain used on a steel or concrete piling with a maximum cross-section dimension of 24 inches or less will provide about 5 dB of noise reduction. When these parameters are used in NMFS pile driving model, the radial distance from the pile to the point where sound exposure level (SEL) is below 187 dBSEL is 27 meters. The radial distance to the point where SEL is below 183 dBSEL is 87 meters and the radial distance to the point where sound pressure is below 150 dBRMS is 2261 meters.

Since these water quality degradations only exists during pile driving, the effect to critical habitat depends entirely on the presence, proximity, size, and anatomy of fish relative to the concentration and duration of the suspended sediment (Newcombe and Jensen, 1996) and the intensity and characteristics of the sound (Popper and Hastings, 2009; Yelverton et al., 1975).

Structural Effects.

The NWA Dock 1 and the vessels moored at the dock are over-water structures that both obstruct salmonids, and attract salmon predators to the shallow water migration critical habitat of subyearling salmon that travel through the LCR estuary along the shoreline. Because this project is the repair of an existing structure, the effect that is caused by the proposed action is the extended duration of these impacts into the future – beyond the lifespan of the existing, deteriorating structure. Although it is not easy to precisely parse the effects between those two timeframes (near term and future/permanent), it should be assumed that the effects we describe here as effects of the action do not include effects of the structure in the near term.

The NWA dock and moored vessels create a shaded zone that salmon are reluctant to enter and that creates favorable ambush habitat for piscine predators of juvenile salmon such as pike minnow[1], smallmouth bass and largemouth bass. The shade and reduced river flow velocity in the wake behind the piles are exploited by piscine predators. Martinelli and Shively (1997) found pike minnow in all of the Columbia River locations that they studied with water velocities of less than 1 meter per second. Faler et al. (1988) monitored the movements of 23 pike minnows below

[1] Pike minnow use water with less than 8 ppt salinity which exists in the Columbia River above RM 28 (http://www.ldeo.columbia.edu/~orton/salt_intrusion.html).

McNary Dam and found them to use habitats with velocities ranging from 0 to 0.70 meter per second. Smallmouth bass in McNary reservoir also preferred slow-velocity habitats (Tabor et al., 1993) and Pribyl et al. (2005) report that smallmouth bass in the nearshore utilized pilings and floating structures. Rondorf et al. (2010) cites studies that pike minnows and smallmouth bass seek out low velocity habitats and utilize overwater structures for cover. Therefore NMFS assumes that the NWA dock and vessels will be used by piscine predators to ambush juvenile salmon. In addition, migrating salmon smolts that select to swim around the NWA dock will be more vulnerable to avian predators that perch on the dock or on moored vessels. Piscivorous birds that feed on juvenile salmon in the Columbia River Basin include Caspian terns, Double Crested cormorants, California gulls and ring billed gulls. The extended life of the NWA dock and vessels extends conditions that encourage the presence of avian predators that degrade the passage PBF and extends the displacement of benthic communities by piles.

Effects to Listed Fish.

The effects of the proposed action on listed species are: 1) Exposure of rearing or outmigrating Chinook salmon smolts to the temporary effects on water - suspended sediment from pile removal and installation and sound pressure waves from pile driving, and 2) Roughly 4 decades[2] of additional exposure of future rearing and outmigration cohorts of Chinook and chum salmon smolts to shade from the repaired overwater structure and predators taking advantage of the repaired overwater structure.

A third effect to listed fish is from the consequences of the proposed action, namely the extended duration of vessel activity associated with the dock and in particular, wake stranding of Chinook and chum salmon smolts by ships transiting to and from the dock in the future.

1) Exposure and Response to Construction Effects.

Although the outmigration of most juvenile salmon does not coincide with the in water work window, a fraction of emigrating juvenile fall Chinook from the SR, LCR and UWR overwinter in the lower Columbia River before completing their migration in the spring (Connor et al., 2005) and it is likely that a small number of these fish will be in the action area during the work window. The out-migration time of each fall Chinook ESU spreads out over time and these fish migrate along the shorelines so some will have to pass near the pile driving. Thus, we assume that some listed SR, LCR and UWR Chinook salmon will be present during the work window to be exposed to the construction effects of the proposed action. Using the approach described in Appendix 1, the steady, lineal density of fish at the NWA dock is 20 fish per kilometer or about 1.3×10^{-4} fish per square meter in a 1,000 meter long by 150 meter wide control volume centered on the NWA dock.

Direct Injury from Impact Pile Driving Sound

Likelihood of Exposure: For impact pile driving in rearing habitat, accumulated SEL is a measure of the risk of injury from exposure to multiple pile strikes over pile driving work periods separated by 12 hours (sufficient time for fish to recover from sub-injurious exposure to high noise levels). For an impact pile driving in migration habitat, fish are moving past the pile

[2] NMFS estimate of the average time between major repair events for overwater structures.

driver without stopping and are exposed to just a fraction of the total impacts for the day. Subyearling Chinook in the Lower Columbia River between October and December are a mixture of smolts that are migrating to the Ocean and juveniles that have paused downstream migration to overwinter in the estuary. Some fish will be exposed to a whole workday of pile driving impacts while other fish will only be briefly exposed to pile driving impacts as they travel past the pile driving. We anticipate that on average a fish would likely only be exposed to approximately 750 strikes during a 15 minute window of time. Proofing a single pile would require 750 strikes over an approximately 15 minute period. This period would be followed by a 45 to 100 minute pause in driving while the next pile is prepared for installation. A fish in the vicinity of construction area would be able to move far downstream during this 45 to 100 minute pause, thus limiting their likely exposure to a maximum of 750 strikes over 15 minutes.

Proofing each 16 inch diameter pile with 750 strikes creates a 24,000 square meter zone around the pile where fish less than 2 grams would accumulate sound pressure greater than 183 dB_{SEL} and become injured or killed. Each impact pile driving will expose 0.00013 fish per square meter times 24,000 square meters equals 3 fish being exposed to sound pressure levels greater than 183 dB_{SEL}. Impact pile driving 70 piles will expose 3 fish per pile times 70 piles equals 210 fish to sound pressure levels greater than 183 dB_{SEL}.

Magnitude of Response: An accumulated sound exposure level (SEL) of 183 dB (re: 1µPa2·sec) for fish with swim bladders weighing less than 2 grams will result in harm or injury. Fish with swim bladders, such as salmonids and sturgeon, can be injured by sounds with the sharp pressure peak (Caltrans 2001) created during impact pile driving because the corresponding longitudinal, mechanical waves mechanically squeeze and then expand the fish swim bladder, causing it to rupture and damage other organs (Halvorsen et al., 2012). Fish exposed to these waveforms show blood in the abdominal cavity and maceration of their kidney tissues (Caltrans, 2001; Yelverton et al., 1975). Other injuries include hemorrhage and rupture of internal organs and damage to the auditory system. Death can be instantaneous, happen within minutes or happen several days after exposure. Fish without swim bladders, such as eulachon, have been shown to be much less affected by pile-driving noise.

Consequence of Exposure and Response to Individual Fitness: It is reasonably certain that Chinook smolts will be exposed to impact pile driving sound pressure waves with sufficient amplitude and frequency to injure or kill individual fish.

Behavioral Effects from Impact Pile Driving Sound

Impact pile driving affects fish behavior at lower noise levels than levels that injure fish (183 $dB_{SEL}$for fish with swimbladders weighing less than 2 grams). The root mean square (RMS) of sound pressure levels (SPLs) is commonly used in behavioral studies. The FHWG (2008) presumes that SPLs in excess of 150 dB_{RMS} (re: 1µPa) are likely to elicit temporary behavioral changes, such as a startle response, or other behaviors indicative of stress and recommends this value as a threshold for possible behavioral effects.

Likelihood of Exposure: Proofing each 16 inch diameter pile with 750 strikes creates a 2.2 kilometer long zone upstream and downstream of the pile where fish will be exposed to sound greater than 150 dB_{RMS}. Each impact pile driving will expose 20 fish per kilometer times 4.4 kilometers equals 88 fish exposed to sound pressure levels greater than 150 dB_{RMS}. Impact pile

driving 70 piles will expose 88 fish per pile times 70 piles equals 6,160 fish to sound pressure levels greater than 150 dB_{RMS}.

Magnitude of Response: While SPLs between 150 dB_{RMS} and 183 dB_{SEL} are unlikely to lead to permanent injury, they can still result in lethal effects by increasing the vulnerability of individual fish to predation. Feist et al. (1996) noted that juvenile pink and chum salmon exposed to pile driving noise were less likely to startle and flee when approached by an observer. Popper (2003) suggests that behavioral response of fishes to loud sounds may include swimming away from the sound source, thereby decreasing potential exposure to the sound, or "freezing" (staying in place), thereby becoming vulnerable to possible injury. Based on the above information, NMFS uses an SPL of 150 dB_{RMS} (re: 1µPa) as a guideline for when behavioral effects can be expected.

Consequence of Exposure and Response to Individual Fitness: It is reasonably certain that the exposure of 6600 fish to sound pressure greater than 150 dB_{RMS}, the alteration of behavior will cause some fraction of these fish to behave in a way that they may be injured or killed by predators.

Effects from Vibratory Pile Activities

Underwater noise from vibratory pile driving and extraction is not expected to have measurable effects on the species considered in this consultation. Vibratory pile driving produces a low level continuous noise (Duncan et al., 2010) that has not been linked to injury to fish. While noise levels from vibratory pile driving have been shown, in some circumstances, to exceed the behavioral threshold of 150 dB_{RMS} (re: 1µPa) they generally do not exceed the injury threshold of 206 dB_{peak} (re: 1µPa) (Caltrans, 2007; Rodkin and Reyff, 2007). Moreover, as reported by (Caltrans, 2007), the loudest SPLs produced by vibratory driving of 72 inch steel piles yielded underwater sound levels of 180 dB_{RMS} (re: 1µPa) and 195 dB_{peak} (re: 1µPa). Here, the pile sizes are significantly less than 72 inches. Thus, considering these data (Caltrans, 2007), vibratory installation of up to eight pilings (16-inch diameter hollow, steel and 14-inch H-type steel) per day between sunrise and sunset are expected to produce SPLs below the NMFS agreed upon injury threshold and are not expected to exceed (or only marginally so) the 150 dB_{RMS} (re: 1µPa) threshold for behavioral effects.

We estimated above that the average suspended sediment concentration from vibratory pile driving pile driving will be about 25 milligrams per liter and that there will be suspended sediment plumes created and dispersed by river currents throughout the work day as piles are removed. We expect that suspended sediment plumes will exist as long as the vibratory pile driver is operating and that they will dissipate within a few minutes after the vibratory pile driver stops.

Likelihood of exposure: Because we postulate a small Chinook salmon density around the work site, it is likely that some fish will be exposed to these suspended sediment plumes.

Magnitude of response: Newcombe and Jensen (1996) show that the response of juvenile salmon to a suspended sediment concentration of 25 milligrams per liter will be a decrease in foraging success while the plume exists. Since the plumes are intermittent, juvenile salmon rearing around the work site will likely take up less food than salmon rearing farther away from the work site.

Consequence of exposure and response: Fish rearing around the work site could experience a slight decrease in growth from their exposure and response to suspended sediment from vibratory pile driving relative to fish in the river at the same time farther from the work site. However, this effect will be minimal.

We estimated above that vibratory removal of creosote treated piles increases the bioavailability to fish of the polynuclear aromatic hydrocarbon (PAH) compounds that have undergone phase transfer from the pile creosote to the sediment surrounding the pile because vibratory pile driving transfers some of this sediment up into the water column. Low molecular weight PAHs are acutely toxic to fish. High molecular weight PAHs are not acutely toxic to fish but can cause cancer and reduced disease resistance in the exposed fish or mutations in their offspring (Johnson et al., 2007a).

Likelihood of exposure: Because we postulate a small Chinook salmon density in the water column around the work site, it is likely that some of these fish will be exposed to PAH compounds in the water column during vibratory pile extraction.

Magnitude of response: We expect that the concentration of low molecular weight PAH in the water column from creosote pile removal will be too low to cause acute toxicity in exposed salmon. Over decades the supply of low molecular weight PAHs in creosote piles is reduced by leaching and it is unlikely that the two phase transfer exposure pathway (creosote to sediment to dissolved sediment) described here can supply acutely toxic concentrations of low molecular weight PAHs in flowing water (Johnson et al., 2007b). We expect that fish exposed to high molecular weight PAHs in the water column will take up some molecules sorbed to dissolved organic matter that passes through their gills or eaten with their prey. Fish can metabolize and excrete PAHs so they don't bioaccumulate but fish exposed to high molecular weight PAHs will have a slightly increased risk of developing cancer or of producing offspring with mutations that affect their survival if they to spawn (Johnson et al., 2007a).

Consequence of exposure and response: The PAH from removal of creosote piles slightly increases the risk of that exposed salmon will die from cancer or decreased resistance to another disease at a later time in their lives or that they will produce offspring with mutations that decrease their likelihood of survival. However, these effects will be minimal.

2) Exposure and Response to Effects of the Structure.

Permanent effects of the proposed action on listed species are caused by the temporal extension of an overwater structure that provide advantages to piscine and avian predators over their juvenile salmon prey and a slight increase in energy expenditure and vulnerability for salmon that select to swim around rather than beneath the structure. These advantages are shade (from the structure and associated vessels) and a flow wake on the back side of piles where predators can hide and ambush juvenile salmon. The reduced light regime under and around overwater structures and vessels improve hunting conditions for ambush predators like the pike minnow. Reduced light allows the predator to hide in shaded and lower velocity water from prey and ambush juvenile salmonids swimming around as well as under the dock. Swimming from light to shade decreases visual ability in juvenile salmon and steelhead so they are less likely to see ambush piscine predators. Petersen and Gadomski (1994) found the rate of predation by northern pikeminnow on subyearling Chinook salmon was inversely related to light intensity in laboratory studies, and five times more salmon were eaten in the darker setting than in the lighter conditions

examined. These predator advantages decrease the likelihood that individual juvenile outmigrant salmonds will survive their migration to saltwater. In general sub-yearling Chinook salmon and chum salmon rear and migrate in the stream channel margins (Bottom et al., 2011; Dauble et al., 2003; Dawley et al., 1986; McCabe et al., 1986; Weitkamp et al., 2012) whereas yearling Chinook, coho and sockeye salmon and juvenile steelhead generally travel between Bonneville and the ocean in the faster flowing water of the main channel (Roegner et al., 2012). This effect will be a persistent condition for the life of the structures, and the increased risk of predation will affect all future cohorts of the SR fall Chinook, LCR Chinook, UWR Chinook and CR chum ESUs/DPSs,, but it is difficult to estimate how many individuals from among these species in each out-migration will become prey to the piscivores that rely on these structures.

A related effect is that the NWA dock and moored vessels will divert some migrating smolts away from the shore where they are more vulnerable to avian predators that perch on the dock. Although the detour is small for each individual, there are many overwater structures in the Lower Columbia River, each adding to the length of the migration path of an entire ESU resulting in a significant increase overall in the total amount of energy that the ESU must find in order to complete migration. Piscivorous birds that feed on juvenile salmon in the Columbia River Basin include Caspian terns, Double Crested cormorants, California gulls and ring billed gulls. Piscivorous bird predation is primarily a problem in the estuary where LCR salmon and steelhead smolts migrate in spring pulses during tern and cormorant breeding. Colonies with more than 100 breeding pairs of California gulls, ring-billed gulls, glaucous winged western gull hybrids, Caspian terns or Double Crested cormorants are on East Sand Island (river mile 5), Rice Island (river mile 21). Caspian terns disproportionately consume smolts in the estuary within 19 miles of their breeding colony (Lyons et al., 2007). Double-crested cormorants have a foraging range of around 18 miles (Anderson et al., 2004). Fortunately, the NWA dock is approximately at Columbia River mile 80, outside the range of nesting terns on Rice Island and Miller Sand Spit. Therefore, we do not expect SR fall Chinook, LCR Chinook, UWR Chinook and CR chum to be caught by avian predators from the NWA dock.

Ship Wake Stranding

A consequence of the proposed action is the continuation of baseline ocean going vessesl (OGV) traffic on the Columbia River to and from the NWA dock into the future. OGVs produce long period wake waves that can entrain small fish near the shoreline, carry them onto beaches and leave them stranded above the point where normal waves would return them back to the channel. Ship wake stranding is a primary contributor to a low-priority limiting factor for ocean type LCR Chinook salmon and Columbia River chum (NMFS 2011d).

Plas Newydd LLC sponsors the Wapato Valley Mitigation and Conservation Bank at the mouth of the Lewis River (upstream of the NWA dock). They monitored ship wake wave stranding along the Columbia River shoreline at river mile 87 for the past two years. Their data shows a pattern of stranding events during lower Columbia River water surface elevations from early January through early April. This time coincides with juvenile fish presence (specifically 30 – 50 mm fall Chinook salmon fry). On average, 27.3 percent of OGVs stranded an average of 10 salmonids per OGV passage (ranging from 2 to 300 fish) (K. Jorgensen pers. comm, Plas Newydd LLC unpublished data 2020). Pearson et al. (2006) reported that 36 percent, 53 percent and 15 percent of 126 deep-draft vessels in the Lower Columbia River in the spring and summer

of 2004 and the winter and spring of 2005 stranded fish at County Line Park, Barlow Point and Sauvie Island respectively. They noted different wave draw down and surge from different vessel size, speed and bow configurations and concluded that fish stranding most often occurred with larger vessels such as bulk carriers, container ships, oil tankers, and car carriers. Pearson et al. (2008) identified beach locations with a likelihood of fish stranding by using GIS to combine of channel width, distance from the navigation channel, shielding features, slope, submerged berms in the navigational channel, and fine scale beach. They determined that stranding of juvenile salmonids is likely at approximately 33 miles of beaches upstream of the NWA and very likely at about 8 miles of shoreline upstream of river mile 25.

Likelihood of exposure: Few juvenile Chinook and chum salmon are likely to be exposed to and stranded by long period wake waves from OGVs traveling to and from the NWA dock. Most stranding beaches are upstream of the NWA dock. County Line Park is about 10 miles downstream from the NWA dock and Barlow Point is just one mile downstream from the NWA dock. OGV speeds range from 9 to 15 knots in the Lower Columbia River and 6 to 9 knots while approaching terminals (ICF et al, 2016) so OGVs traveling to the NWA dock will pass County Line Park at 9-15 knots and slow to 6 to 9 knots while passing Barlow Point. Pearson (2006) estimated that decreasing a 77-foot long beam ship's speed from 14 knots to 12 knots decreased wake wave height by 63 percent and that ships moving less than 8 knots did not cause wake stranding. OGVs unload aluminum ore at the NWA dock about eight times per year. We expect Chinook and chum salmon off County Line Park will continue to be exposed to long period wake waves from about 3 (36 percent) of the NWA OGVs per year. We do not expect any Chinook or chum salmon near Barlow point to be exposed to stranding waves from NWA dock OGVs.

Magnitude of response: The response of virtually every Chinook and chum salmon stranded by OGV wake waves is death because the waves transport them farther up the beach than normal waves travel so they have no way to be transported back to the channel.

Consequence of exposure and response: We expect that three NWA OGVs will transport a total of 30 Chinook and chum salmon onto the County Line Park beach per year if the Plas Newydd LLC monitoring data is representative of other beaches[3].

2.6 Cumulative Effects

"Cumulative effects" are those effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 CFR 402.02 and 402.17(a)). Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

[3] We acknowledge there are potential problems with this approach. There is considerable uncertainty about the frequency, location, and severity of stranding events. Therefore, any quantitative estimate of wake stranding is likely to be associated with large confidence intervals, and is as likely to overestimate stranding as it is likely to underestimate stranding. We are also aware that the authors of some of the studies we considered warned against projecting their results to other sites or other circumstances. However, given the lack of a better alternative, we think a quantitative approach based on the results of previous studies is the best method to estimate the impact of wake stranding.

Some continuing non-Federal activities are reasonably certain to contribute to climate effects within the action area. However, it is difficult if not impossible to distinguish between the action area's future environmental conditions caused by global climate change that are properly part of the environmental baseline *vs.* cumulative effects. Therefore, all relevant future climate-related environmental conditions in the action area are described in the environmental baseline (Section 2.4).

Non-Federal activities are reasonably certain to contribute to climate effects within the action area. It is difficult to distinguish between the action area's future environmental conditions caused by global climate change that are properly part of the environmental baseline vs. cumulative effects. However, it is reasonably certain that over the additional service life of the project, that climate effects such as modified water temperatures, altered river hydrograph, and shifting salinity will all exert more influence on the habitat quality and related carrying capacity.

The NMFS expects State and private activities near and upriver from the proposed action will contribute to cumulative effects in the action area. Therefore, our analysis considers: 1) effects caused by specific future non-federal activities in the action area. 2) effects in the action area caused by future non-federal activities in the Columbia basin.

Development trends indicate that upland private and public actions that affect the action area will continue. NMFS looked for but did not find any proposals for specific, local projects proposals within or adjacent to the action area that would not require a Federal permit consultation. However, as the population in and around Longview grows, demand for residential development and infrastructure in the upland and riparian zones is also likely to grow. We believe the majority of environmental effects related to future growth will be linked to land-use changes and increased impervious surface that can affect shallow water habitat quality and deliver contaminants to substrates near the action area. State, county and city regulations should minimize and mitigate for the adverse effects of this development so that the overall environmental quality of the action area remains constant, albeit degraded relative to its restored condition.

Similar activities outside of the action area will influence conditions in the action area. Approximately 1.13 million people live along the Lower Columbia River, concentrated largely in urban parts of the Lower Columbia River (U.S. Census Bureau 2017). The legacy of resource-based industries (e.g., agriculture, hydropower facilities, timber harvest, fishing, and metals and gravel mining) caused long-lasting environmental changes that harmed ESA-listed species and their critical habitats. Stream channel morphology, roughness and cover, estuarine rearing habitats, wetlands, floodplains, riparian areas, water quality, fish passage, and habitat refugia has been degraded throughout the Lower Columbia River basin. Those changes reduce the ability of populations of ESA-listed species to sustain themselves in the natural environment by altering or interfering with their behavior in ways that reduce their survival throughout their life cycle.

While widespread degradation of aquatic habitat associated with intense natural resource extraction is no longer common, ongoing land management actions are likely to continue to adversely affect the estuary and retard natural recovery of aquatic habitat in the Columbia River basin including the action area. This trend is somewhat countered by non-federal aquatic habitat restoration occurring in the Lower Columbia River. The Lower Columbia River Partnership has over 100 regional partners in the Lower Columbia River and has completed 199 projects with a

total of 22,685 acres. Projects include land acquisitions and conservation easements, adding large logs to streams to create fish habitat, planting trees to shade and cool streams, and removing barriers to fish passage (LCEP 2017). Still, when considered together, the net cumulative effects are likely to have an adverse effect on salmon and steelhead.

2.7 Integration and Synthesis

The Integration and Synthesis section is the final step in our assessment of the risk posed to species and critical habitat as a result of implementing the proposed action. In this section, we add the effects of the action (Section 2.5) to the environmental baseline (Section 2.4) and the cumulative effects (Section 2.6), taking into account the status of the species and critical habitat (Section 2.2), to formulate the agency's biological opinion as to whether the proposed action is likely to: (1) Reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing its numbers, reproduction, or distribution; or (2) appreciably diminish the value of designated or proposed critical habitat as a whole for the conservation of the species.

All of the species affected by the proposed action are threatened with extinction, and conditions throughout their designated critical habitat, including within the action area, are diminished quantitatively and qualitatively, in a manner that inhibits their recovery. The environmental baseline of the Columbia River estuary is degraded. Estuarine and nearshore habitat, floodplain connectivity and function, channel structure, riparian areas, stream substrates, streamflow, fish passage, water quality are all degraded. Predation on salmon smolts, facilitated by overwater structures, is a limiting factors to the recovery of CR chum and UWR Chinook salmon. The natural recovery of aquatic habitat PBFs important to the survival and recovery of listed species continues to be inhibited by the anthropogenic changes motivated by economic demands on the estuary.

Climate change affects the Lower Columbia River. Direct effects of higher temperature include mortality from heat stress, changes in juvenile growth and development rates, decreased disease resistance and shifts in seasonal timing of important life history events (adult migration, spawning, fry emergence timing, and the juvenile migration). Indirect effects on salmon mortality, growth rates and movement behavior stem from changes in the estuarine habitat structure, the invertebrate and vertebrate food supply and abundance of predation. Both direct and indirect effects of climate change will vary among Pacific salmon ESUs and among populations in the same ESU. Adaptive change in any salmonid population will depend on the local consequences of climate change as well as ESU-specific characteristics and existing local habitat characteristics (NWFSC, 2015b).In this context we consider the added effects of the proposed action on habitat, and on species.

Effects on Critical Habitat

The critical habitat effects of the proposed action are; 1) The generation of suspended sediment contaminated with PAH from creosote and sound pressure waves by approximately 18 days of pile driving, and 2) Extending the presence of an obstruction in the shallow water habitat represents a prolonged hazard to safe passage in migration, and prolonged structure-associated habitat impacts in rearing habitat (e.g shade).

1) Vibratory pile driving at will generate a suspended sediment concentration averaging 25 mg/L. The suspended sediment is likely contaminated with PAHs that transferred from the creosote treated piles. Although the PAH concentration in sediment is likely low and the suspended sediment concentration is also low, PAHs in the water column are more bioavailable to fish than PAHs in creosote or the sediment around the piles. Suspended sediment will be advected and dispersed downstream as a plume by the current. Impact pile driving will produce a 15 minute long, 24,000 square meter SEL area around each pile. Both aspects of water quality/ aquatic habitat will recover to the baseline level of habitat conditions within minutes to hours after construction ceases, indicating that overall, these features of critical habitat are not degraded in a manner that reduces conservation value of the action area.

2) Because this project is the repair of an existing structure, the effect that is caused by the proposed action is the extended duration of these impacts into the future -- beyond the lifespan of the existing, deteriorating structure. The overwater structure is man-made habitat that affects the migration of smolts which travel along the shoreline, or that extends their migration path length by forcing them to swim around the structure. In addition, the overwater structure provides ambush habitat to pikeminnow and bass predators of juvenile fall Chinook and chum salmon and avian predators. These permanent effects will occur during the extended duration of the structure, which is attributable to the proposed action and they diminish safe juvenile passage throughout the action area. Conservation value will be maintained at a functional, but suboptimal level.

Species Exposure to Temporary Effects.

Juvenile fall Chinook salmon rear in and migrate through the action area as subyearlings during the in water work window. Juvenile Chinook salmon in the action area during fall are the only fish likely to be exposed to the temporary effects of vibratory and impact pile driving because, as explained below, other Chinook life stages and chum salmon will not be in the action area during construction.

Lower Columbia Chinook Salmon. Juvenile fall chinook salmon comprise 23 of the 32 populations of this ESU. Most of these populations are at very high risk of extinction and only a few populations are viable. LCR Chinook salmon are present in the action area during the in water work window, thus they will exposed to the temporary effects of the proposed action.

The Upper Willamette River Chinook salmon ESU is comprised of 7 populations, most at a very high risk of extinction. UWR Chinook are spring Chinook but some subyearlings from the populations migrate to the estuary in the fall and overwinter in the estuary before entering the ocean in the spring (NMFS 2011). Only these atypical fish are likely to experience the temporary effects of the proposed action.

The Snake River fall Chinook ESU is one extant population at moderate risk for extinction. This population will experience the temporary effects of the proposed action because some juveniles pause migration to overwinter in the LCR before resuming migration in the spring.

Columbia River Chum. Juvenile Columbia River chum salmon migrate past the action area as subyearlings outside of the in-water work window. CR chum salmon are therefore not likely to be exposed to the temporary effects of pile driving. The Columbia River chum salmon ESU is comprised of 17 populations. Most are at a high or very high risk of extinction.

Impact pile driving will produce a 15 minute long, 24,000 square meter SEL area around each pile. Any subyearling salmon in that area during the time is expected to be injured or killed. Given the size of the SEL zone around impact driven piles where accumulated sound pressure is greater than 183 dB and the number of piles proposed to be impact driven, it is likely that a small number of subyearling Chinook will be killed or injured. If we extrapolate that this will occur at each pile being proofed with impact driving, about 210 subyearling fish are likely to be injured or killed during construction. This single episode of about 210 total fish injured or killed is likely to be dispersed across multiple Chinook salmon populations. Even if all injured or killed fish were from the same population, the number is small enough that no discernible effect will result in the returning cohort of adult fish, so that productivity will not be impaired by this reduction in abundance. Impact pile driving is expected to only affect fish at the tail of fall Chinook migration time distribution and the SR and UWR Chinook salmon that overwinter in the estuary.

A fraction of PAHs from creosote treated piles transfers from the pile to the sediment surrounding the pile. Removing these piles with a vibratory pile driver causes the PAH contaminated sediment around the pile to become suspended in the water column. Given the estimated lineal density of subyearling Chinook salmon in the LCR, it is likely that some fish will be exposed to this suspended sediment but it is unlikely that suspended sediment concentration or the PAH concentration will reach levels and durations that harm these fish. Too few fish from any one population will be exposed to suspended sediment and PAHs to affect the population viability characteristics of any ESU.

Species exposure to permanent effects.

The proposed action is intended to, and expected to, restore the structural integrity of the structure and thus meaningfully extend the life of the structure. As a result, the effects of the structure will now occur for longer into the future, affecting many additional cohorts of listed fish. These additional effects result from the structures being repaired, i.e., are caused by the proposed action, and thus are effects of the action.

All populations of all four species will occasionally experience effects from the structure and vessels during their rearing and outmigration. The structure and vessels produce shade that can impair salmonid vision so that they are less able to detect the predatory fish and the juvenile migrating fish also respond to the structure by delaying migration when they encounter the structure and also by migrating around the structure in deeper water, all of which makes them more susceptible to predators that rely on the structure for ambush habitat. The structure's presence in the aquatic environment into the future therefore reduces abundance per population for the same duration as the structures extended lifespan. However, too few fish from any one population will be injured or killed as a result of the structure to affect population viability characteristics of the ESU as a whole. As a limiting factor to recovery, piscine predation is just one component of salmonid predation distributed over the entire length of the Columbia and Snake Rivers.

Under some river conditions OGVs traveling in the Columbia River produce long period wake waves that travel far up low slope beaches. Small fish in the nearshore, including subyearling Chinook and chum salmon, are carried by these waves up onto the beach and left stranded when the wave recedes. Just as the proposed action will (temporally) extend the useful life of Dock 1, it will relatedly extend the duration of OGV travel in the Columbia River to the Dock 1. It will

thereby extend the number of fish cohorts subject to stranding and death. All populations of all four species will occasionally experience the effects of vessel use of the structure during their outmigration, but the fish most likely to experience episodes of wake stranding from the continued vessel use of the structure are again, juvenile fall Chinook salmon and CR chum. Nevertheless, too few fish from any one population will be killed as a result of wake stranding associated with the proposed action to affect the population viability characteristics of the ESU.

The cumulative effects include restoration and recovery actions, so that we can reasonably anticipate that some beneficial effects will improve habitat and juvenile to adult survival over the life of the project, however we also reasonably expect contemporaneously negative habitat pressures from climate change and continued and intensifying upland development. Taken together, we expect the negative cumulative effects may outweigh the positive effects.

Considering the current status of all salmon and steelhead populations the degraded environmental baseline within the action area, and cumulative effects the proposed action itself is not expected to affect their distribution, diversity, or productivity of any of the populations or further degrade baseline conditions or limiting factors. The effects of the action will be too small in scale and too minor to have a measurable impact on the affected populations. Because the proposed action will not reduce the productivity, spatial structure, or diversity the affected populations, the action, even when combined with additional pressure from cumulative effects, the project and its interrelated activities will not appreciably affect the status of any of the listed species considered in this opinion.

2.8 Conclusion

After reviewing and analyzing the current status of the listed species and critical habitat, the environmental baseline within the action area, the effects of the proposed action, the effects of other activities caused by the proposed action, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of LCR Chinook salmon, UWR Chinook salmon, SR fall-run Chinook salmon, or Columbia River chum salmon or destroy or adversely modify their designated critical habitat.

2.9 Incidental Take Statement

Section 9 of the ESA and Federal regulations pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without a special exemption. "Take" is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. "Harm" is further defined by regulation to include significant habitat modification or degradation that actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding, or sheltering (50 CFR 222.102). "Incidental take" is defined by regulation as takings that result from, but are not the purpose of, carrying out an otherwise lawful activity conducted by the Federal agency or applicant (50 CFR 402.02). Section 7(b)(4) and section 7(o)(2) provide that taking that is incidental to an otherwise lawful agency action is not considered to be prohibited taking under the ESA if that action is performed in compliance with the terms and conditions of this ITS.

2.9.1 Amount or Extent of Take

In the biological opinion, NMFS determined that incidental take is reasonably certain to occur as follows:

1) Incidental take from temporary effects: Juvenile Chinook salmon in the action area in the fall will be harmed by SEL from impact pile driving. Quantifying the number of juvenile Chinook salmon that will be harmed by SEL is not practicable because the distribution and abundance of fish in the action area changes over time, and because not all fish respond to habitat impacts the same. Because of the high variability in fish presence, determining the number of juvenile Chinook that will be in the action area and exposed to SEL during pile driving is extremely difficult, NMFS therefore uses a surrogate that serves the same role as an estimate of the actual number of Chinook harmed or killed in that it is a) quantifiable b) can be monitored in real time so that it serves its role as a meaningful reinitiation trigger and c) is causally related to the harm/death. In this case the surrogate is the total number of piles proofed for the project. Because this number is directly related to the size of the SEL zone where subyearling salmon will be injured or killed, and juvenile Chinook salmon are presumed to be migrating or rearing in the estuary at all times, the number of impact pile driving blows is directly related to the Chinook salmon are exposed to and harmed or killed by impact pile driving. If the number of piles proofed exceeds 70 the take limit is exceeded and the Opinion must be reinitiated. Although this surrogate is somewhat coextensive with the proposed action, it nevertheless serves as an effective reinitiation trigger because, pile numbers can be tracked on an ongoing basis and if they installed 70 and more piles were needed then, by definition, the project would not be complete and reinitiation could meaningfully occur.

2) Incidental take from permanent effects. As explained above, as a result of the proposed action, the effects of the structure will occur for longer into the future (approximately 40 years), affecting many additional cohorts of SR fall Chinook LCR Chinook, UWR Chinook and CR chum. More specifically, over the next 40 year period following the completion of this action, it is reasonably certain that these species of juvenile Chinook and chum salmon migrating beneath the dock will be harmed (harm is a habitat modification that results in injury or death) when they are killed by piscine predators. Quantifying the number of juvenile Chinook and chum that will be killed over the next 40 years is not practicable because the annual abundance of cohorts cannot be accurately predicted, and the number that are successfully preyed upon is impossible to determine. Instead, NMFS uses a surrogate that serves the same role as an estimate of the actual number of Chinook and chum salmon killed in that it is quantifiable, can be monitored in real time so that it serves its role as a reinitiation trigger, and is causally related to the harm. In this case the surrogate is the 1,200 square meter surface area of the dock over water less than 20 feet deep. If the surface area of the NWA dock over water less than 20 feet deep exceeds 1,200 square meters, the take limit is exceeded and the Opinion must be reinitiated. This surrogate is causally related to the expected take because the surface area correlates to the number of predators that use the dock to ambush juvenile salmon. Although this surrogate is somewhat coextensive with the proposed action, it nevertheless serves as an effective reinitiation trigger because it can be readily monitored and if exceeded, the Corps can seek compliance post construction.

3) Incidental take from OGV vessel traffic. OGVs traveling to and from the NWA dock over the next 40 years will produce long period waves that may cause injury and death to Chinook and chum salmon from ship wake stranding. At this time, the limited data associated with wake stranding is considered insufficient to provide an exact take estimate, as the conditions that cause stranding wakes depends on a large number of variables, and the numbers stranded depends on the timing of the wakes and the variable number of fish that may be present. NMFS analysis and no jeopardy determination were both based on the fact that the number of OGVs traveling to and from the dock are and will continue to be a very small fraction of OGV traffic in the Lower Columbia River. NMFS is using the product of an average of eight loaded NWA OGV trips per year past County Line Park for 40 years as a surrogate for quantifying take consistent with 50 CFR § 402.14(i)(2). Using 320 loaded NWA OGV trips past County Line Park as a surrogate establishes a clear standard for determining when the level of anticipated take has been exceeded. For example, if the number of loaded NWA OGV trips past County Line Park exceeds 320 in less than 40 years, we expect that anticipated effects and resulting take would also be exceeded. Thus, even though the surrogate mirrors the average amount of assumed vessel traffic, it nevertheless functions as an effective check on the ongoing validity of the jeopardy analysis (which underpins the take exemption) because it is an annual measurement that can be monitored by the applicant. That means there is an opportunity each year to check whether the assumption of a total of 320 loaded NWA OGV trips past County Line Park over 40 years has been exceeded. Thus, we believe that OGV trips is an easily assessed, effective and reliable take surrogate that meets the legal standards as they relate to a reinitiation trigger.

2.9.2 Effect of the Take

In the biological opinion, NMFS determined that the amount or extent of anticipated take, coupled with other effects of the proposed action, is not likely to result in jeopardy to the species or destruction or adverse modification of critical habitat.

2.9.3 Reasonable and Prudent Measures

"Reasonable and prudent measures" are nondiscretionary measures that are necessary or appropriate to minimize the impact of the amount or extent of incidental take (50 CFR 402.02).

1) Minimize incidental take from impact pile driving.

2) Minimize incidental take from piscine predation.

3) Ensure completion of a monitoring and reporting program to confirm that the take exemption for the proposed action is not exceeded, and that the terms and conditions in this incidental take statement are effective in minimizing incidental take.

2.9.4 Terms and Conditions

The terms and conditions described below are non-discretionary, and the entity indicated below must comply with them in order to implement the RPMs (50 CFR 402.14). There is a continuing duty to monitor the impacts of incidental take report the progress of the action and its impact on the species as specified in this ITS (50 CFR 402.14). If the entity to whom a term and condition

is directed does not comply with the following terms and conditions, protective coverage for the proposed action would likely lapse.

1) The following terms and conditions implements reasonable and prudent measure 1: The applicant shall:

a) Use a bubble curtain to attenuate sound pressure during impact pile driving.

b) Use impact pile driving to proof no more than 4 piles per day and no more than 70 total steel pipe piles. Monitor the number of impact blows delivered to each piles each day.

2) The following term and condition implements reasonable and prudent measure 2):

a) Ensure that the surface area of the dock over water less than 20 feet deep is less than 1,200 square meters.
b) The applicant shall ensure that the replacement of timber piles with stronger steel pipe piles reduces ambush habitat for piscine predators of juvenile salmon by decreasing the total number of piles supporting the dock by at least 11 piles.

3) The following term and condition implements reasonable and prudent measure 3):

a. Reporting. USACE and the applicant shall report all monitoring items, to include, at a minimum, the following:
   ii. Pile installation. Report the number of strikes per pile, the number of piles installed, the type of piles installed, the type and use of sound attenuation device, and type of hammer used. Report if pile driving occurs for more than a 12 hour consecutive period.
   iii. Overwater structure. Report the surface area of the part of the structure that is over water less than 20 feet deep.
   iv. Dredge area. Report the final area dredged does not exceed 41.5 acres.
   v. Wake Stranding. Report the annual number of loaded NWA OGV trips past County Line Park.

   Send this report electronically to: projectreports.wcr@noaa.gov; Attention: Tom Hausmann. Include the NMFS Tracking Number WCRO-2015-00006 on the report.

2.9 Conservation Recommendations

No conservation recommendations are identified for this proposed action.

2.10 Reinitiation of Consultation

This concludes formal consultation for the Northwest Alloys, Inc. Dock 1 Repair Project.

As 50 CFR 402.16 states, reinitiation of consultation is required and shall be requested by the Federal agency or by the Service where discretionary Federal agency involvement or control over the action has been retained or is authorized by law and if: (1) The amount or extent of

incidental taking specified in the ITS is exceeded, (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion, (3) the identified action is subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in the biological opinion, or (4) a new species is listed or critical habitat designated that may be affected by the action.

2.11 "Not Likely to Adversely Affect" Determinations

Under the ESA, "effects of the action" means the direct and indirect effects of an action on the listed species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action (50 CFR 402.02). The applicable standard to find that a proposed action is not likely to adversely affect listed species or critical habitat is that all of the effects of the action are expected to be discountable, insignificant, or completely beneficial. Beneficial effects are contemporaneous positive effects without any adverse effects to the species or critical habitat. Insignificant effects relate to the size of the impact and should never reach the scale where take occurs. Discountable effects are those extremely unlikely to occur.

Impact pile driving projects acoustic pressure waves into the Columbia River. The timing of adult salmon upstream migration and juvenile salmon downstream migration is summarized in Table 5. Adult and juvenile SR spring/summer Chinook, UCR steelhead, SR steelhead, MCR steelhead and SR sockeye migrations take place outside of the in water work window so the effects of pile driving to these species are discountable. Eulachon migration and green sturgeon presence in the Lower Columbia River is also outside the in water work window and the effects of the proposed action on these species is discountable.

Adult UCR spring Chinook, SR steehead, MCR steelhead and LCR steelhead migrations may overlap the work window but adult salmon are not likely to be adversely affected by pile driving pressure waves should they swim close to the pile driver, and their migration behavior is not likely to be affected by pile driving noise because they rapidly ascend the Lower Columbia River to reach their natal streams (Groot and Margolis, 1998). Therefore, the effects of pile driving on adults of these four species is expected to be insignificant.

Juveniles and smolts of all nine species (UCR Chinook spring salmon, SR spring/summer Chinook salmon, UCR steelhead, SR steelhead, MCR steelhead, SR sockeye salmon, LCR coho salmon and LCR steelhead) that migrate past the NWA dock won't be affected by impact pile driving because the in water work window makes it extremely unlikely that such migrating smolts would overlap in time and therefore be exposed to the impact pile driving sound pressure waves, thus the effect is discountable.

The proposed action may affect southern resident killer whales indirectly by reducing availability of their primary prey, Chinook salmon. The proposed activities are not expected to produce a measurable effect on the abundance, distribution, diversity, or productivity of Chinook salmon at either the population or species level. Given the total quantity of prey available to southern resident killer whales throughout their range, this reduction in prey is extremely small, and is not anticipated to be different from zero by multiple decimal places (based on NMFS previous analyses of the effects of in-river salmon harvest on Southern Resident killer whales, e.g. NMFS No. WCR-2017-7164). Because the reduction is so small, there is also a low probability that any juvenile Chinook salmon killed by the proposed activities would have later (in 3-5 years' time) been intercepted by the killer whales across their vast range in the absence of the proposed activities. Therefore, the anticipated reduction of salmonids associated with the proposed action would result in an insignificant reduction in adult equivalent prey resources for southern resident killer whales and an insignificant effect on proposed southern resident killer whale critical habitat.

3. MAGNUSON-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT ESSENTIAL FISH HABITAT RESPONSE

Section 305(b) of the MSA directs Federal agencies to consult with NMFS on all actions or proposed actions that may adversely affect EFH. The MSA (section 3) defines EFH as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." Adverse effect means any impact that reduces quality or quantity of EFH, and may include direct or indirect physical, chemical, or biological alteration of the waters or substrate and loss of (or injury to) benthic organisms, prey species and their habitat, and other ecosystem components, if

such modifications reduce the quality or quantity of EFH. Adverse effects on EFH may result from actions occurring within EFH or outside of it and may include site-specific or EFH-wide impacts, including individual, cumulative, or synergistic consequences of actions (50 CFR 600.810). Section 305(b) also requires NMFS to recommend measures that can be taken by the action agency to conserve EFH.

This analysis is based, in part, on the EFH assessment provided by the the Corps and descriptions of EFH for Pacific Coast salmon (PFMC 2014)**]** contained in the fishery management plans developed by the PFMC and approved by the Secretary of Commerce.

3.1 Essential Fish Habitat Affected by the Project

The proposed action and action area for this consultation are described in the Introduction section to this document. The action area includes areas designated as EFH for various life history stages of Chinook and coho salmon.

3.2 Adverse Effects on Essential Fish Habitat

We conclude that the proposed action will have the following adverse effects of EFH designated for coho and Chinook salmon.

- Short term increase and noise and suspended sediment during pile driving.
- Long term increase in predation from in and overwater structure.

3.3 Essential Fish Habitat Conservation Recommendations

Ensure that applicant implements ESA Term and Condition 1a.

Ensure that the applicant implements ESA Term and Condition 2.

Fully implementing these EFH conservation recommendations would protect, by avoiding or minimizing the adverse effects described in section 3.2, above, approximately 1600 acres of designated EFH for Pacific Coast salmon.

3.4 Statutory Response Requirement

As required by section 305(b)(4)(B) of the MSA, [*insert agency name*] must provide a detailed response in writing to NMFS within 30 days after receiving an EFH Conservation Recommendation. Such a response must be provided at least 10 days prior to final approval of the action if the response is inconsistent with any of NMFS' EFH Conservation Recommendations unless NMFS and the Federal agency have agreed to use alternative time frames for the Federal agency response. The response must include a description of measures proposed by the agency for avoiding, minimizing, mitigating, or otherwise offsetting the impact of the activity on EFH. In the case of a response that is inconsistent with the Conservation Recommendations, the Federal agency must explain its reasons for not following the recommendations, including the scientific justification for any disagreements with NMFS over the anticipated effects of the action and the measures needed to avoid, minimize, mitigate, or offset such effects (50 CFR 600.920(k)(1)).

In response to increased oversight of overall EFH program effectiveness by the Office of Management and Budget, NMFS established a quarterly reporting requirement to determine how many conservation recommendations are provided as part of each EFH consultation and how many are adopted by the action agency. Therefore, we ask that in your statutory reply to the EFH portion of this consultation, you clearly identify the number of conservation recommendations accepted.

3.5 Supplemental Consultation

The Corps must reinitiate EFH consultation with NMFS if the proposed action is substantially revised in a way that may adversely affect EFH, or if new information becomes available that affects the basis for NMFS' EFH Conservation Recommendations (50 CFR 600.920(l)).

4. DATA QUALITY ACT DOCUMENTATION AND PRE-DISSEMINATION REVIEW

The Data Quality Act (DQA) specifies three components contributing to the quality of a document. They are utility, integrity, and objectivity. This section of the opinion addresses these DQA components, documents compliance with the DQA, and certifies that this opinion has undergone pre-dissemination review.

4.1 Utility

Utility principally refers to ensuring that the information contained in this consultation is helpful, serviceable, and beneficial to the intended users. The intended users of this opinion are the Corps. Other interested users could include NW Alloys. Individual copies of this opinion were provided to the Corps. The document will be available within two weeks at the NOAA Library Institutional Repository [https://repository.library.noaa.gov/welcome]. The format and naming adheres to conventional standards for style.

4.2 Integrity

This consultation was completed on a computer system managed by NMFS in accordance with relevant information technology security policies and standards set out in Appendix III, 'Security of Automated Information Resources,' Office of Management and Budget Circular A-130; the Computer Security Act; and the Government Information Security Reform Act.

4.3 Objectivity

Information Product Category: Natural Resource Plan

Standards: This consultation and supporting documents are clear, concise, complete, and unbiased; and were developed using commonly accepted scientific research methods. They adhere to published standards including the NMFS ESA Consultation Handbook, ESA regulations, 50 CFR 402.01 et seq., and the MSA implementing regulations regarding EFH, 50 CFR 600.

Best Available Information: This consultation and supporting documents use the best available information, as referenced in the References section. The analyses in this opinion [*and EFH consultation, if applicable*] contain more background on information sources and quality.

Referencing: All supporting materials, information, data and analyses are properly referenced, consistent with standard scientific referencing style.

Review Process: This consultation was drafted by NMFS staff with training in ESA and MSA implementation, and reviewed in accordance with West Coast Region ESA quality control and assurance processes.

5. REFERENCES

Abatzoglou, J.T., Rupp, D.E., and Mote, P.W. (2014). Seasonal climate variability and change in the Pacific Northwest of the United States. Journal of Climate *27*, 2125-2142.

Anderson, D.D., Roby, D.D., and Collis, K. (2004). Foraging patterns of male and female Double-crested Cormorants nesting in the Columbia River Canadian Journal of Zoology *82*, 13.

Barton, A., B. Hales, Waldbuster, G.G., Langdon, C., and Feely, R. (2012). The Pacific Oyster,Crassostrea gigas, Shows Negative Correlation to Naturally Elevated Carbon Dioxide Levels: Implications for Near-Term Ocean Acidification Effects. Limnology and Oceanography *57*, 12.

Bottom, D.L., Baptista, A., Burke, J., Campbell, L., Casillas, E., Hinton, S., Jay, D.A., Lott, M.A., McCabe, G., McNatt, R.*, et al.* (2011). Estuarine Habitat and Juvenile Salmon: Current and Historical Linkages in the Lower Columbia River and Estuary Final Report 2002-2008 (Seattle, WA: Northwest Fisheries Science Center, National Marine Fisheries Service).

Caltrans (2001). San Francisco – Oakland Bay Bridge East Span Seismic Safety Project Pile Installation Demonstration Project Fisheries Impact Assessment.

Caltrans (2007). Compendium of Pile Driving Sound Data (Sacramento, CA: California Department of Transportation).

Connor, W.P., Sneva, J.G., Tiffan, K.F., Steinhorst, R.K., and Ross, D. (2005). Two Alternative Juvenile Life History Types forFall Chinook Salmon in the Snake River Basin. Transactions of the American Fisheries Society *134*, 13.

Crozier, L.G., Hendry, A.P., Lawson, P.W., Quinn, T.P., Mantua, N.J., Battin, J., Shaw, R.G., and Huey, R.B. (2008). Potential responses to climate change in organisms with complex life histories: evolution and plasticity in Pacific salmon. Evolutionary Applications *1*, 18.

Dauble, D.D., Hanrahan, T.P., Geist, D.R., and Parsley, M.J. (2003). Impacts of the Columbia River hydroelectric system on main-stem habitats of fall Chinook salmon. North American Journal of Fisheries Management *23*, 18.

Dawley, E.M., Ledgerwood, R.D., Blahm, T.H., Sims, C.W., Durkin, J.T., Kirn, R.A., Rankis, A.E., Monan, G.E., and Ossiander, F.J. (1986). Migrational characteristics, biological observations, and relative survival of juvenile salmonids entering the Columbia River estuary, 1966–1983 (Portland, OR: National Marine Fisheries Service).

Dominguez, F., Rivera, E., Lettenmaier, D.P., and Castro, C.L. (2012). Changes in Winter Precipitation Extremes for the Western United States Under a Warmer Climate as Simulated by Regional Climate Models. Geophysical Research Letters *39*.

Doney, S.C., Ruckelshaus, M., Duffy, J.E., Barry, J.P., Chan, F., English, C.A., Galindo, H.M., Grebmeier, J.M., Hollowed, A.B., N.Knowlton*, et al.* (2012). Climate Change Impacts on Marine Ecosystems. Annual Review of Marine Science Annual Review of Marine Science *4*, 26.

Duncan, A.J., McCauley, R.D., Parnum, I., and C. Salgado-Kent (2010). Measurement and Modelling of Underwater Noise from Pile Driving Paper presented at: Proceedings of 20th International Congress on Acoustics (Sydney, Australia).

Feely, R.A., Klinger, T., Newton, J.A., and Chadsey, M. (2012). Scientific summary of ocean acidification in Washington state marine waters. In NOAA Office of Oceanic and Atmospheric Research Special Report.

Feist, B.E., Anderson, J.J., and Miyamoto, R. (1996). Potential impacts of Pile Driving on Juvenile Pink (Oncorhynchus Gorbuscha) and Chum (O. Keta) Salmon Behavior and Distribution (Seattle, WA: University of Washington Fisheries Research Institute), pp. 58.

Ferguson, J.W., Matthews, G.M., McComas, R.L., Brege, R.F.A.A., Gessel, M.H., and Gilbreath, L.G. (2005). Passage of adult and juvenile salmonids through federal Columbia River power system dams (U.S. Dept. Commer.), pp. 160.

Ford, M.J., (editor) (2011). Status review update for Pacific salmon and steelhead listed under the Endangered Species Act: Pacific Northwest, U.S. Department of Commerce, ed., pp. 281 p.
Glick, P., Clough, J., and Nunley, B. (2007). Sea-Level Rise and Coastal Habitats in the Pacific Northwest: An analysis for Puget Sound, southwestern Washington, and northwestern Oregon (Seattle, WA: National Wildlife Federation).

Goode, J.R., Buffington, J.M., Tonina, D., Isaak, D.J., Thurow, R.F., Wenger, S., Nagel, D., Luce, C., Tetzlaff, D., and Soulsby, C. (2013). Potential effects of climate change on streambed scour and risks to salmonid survival in snow-dominated mountain basins. Hydrological Processes *27*, 15.

Groot, C., and Margolis, L. (1998). Pacific Salmon Life Histories (Vancouver, B.C. Canada: UBC Press).

Halvorsen, M.B., Casper, B.M., Matthews, F., Carlson, T.J., and Popper, A.N. (2012). Effects of exposure to pile-driving sounds on the lake sturgeon, Nile tilapia and hogchoker. Proceedings of the Royal Society B Biological Science *249*, 9.

IC-TRT (2003). Independent populations of Chinook, steelhead, and sockeye for listed evolutionarily significant units within the Interior Columbia River domain. Working draft. July.
IPCC (2014). Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, R.K.P.a.L.A. Meyer, ed. (Geneva, switzerland: Intergovernmental Panel on Climate Change), pp. 151.

Isaak, D.J., Wollrab, S., and Chandler, G. (2012). Climate change effects on stream and river temperatures across the northwest US from 1980–2009 and implications for salmonid fishes. Climatic Change *113*, 25.

ISAB (editor) (2007). Climate change impacts on Columbia River Basin fish and wildlife. In Climate Change Report, I.S.A. Board, ed. (Portland, Oregon: Northwest Power and Conservation Council).

Jepson, M.A., Keefer, M.L., and Caudill, C.C. (2015). Migratory behavior, run timing and distribution of radio-tagged adult winter steelhead, summer steelhead, spring Chinook salmon and coho salmon in the Willamette River: 2011-2014 (U. S. Armycorps of Engineers), pp. 117.

Jepson, M.A., Keefer, M.L., Caudill, C.C., Clabough, T.S., and Sharpe, C.S. (2013). Migratory behavior, run timing and distribution of radio-tagged adult winter steelhead, summer steelhead and spring Chinook salmonin the Willamette River-2012 (U. S. ArmyCorps of Engineers), pp. 103.

Johnson, L.L., Arkoosh, M.R., Bravo, C.F., Collier, T.K., Krahn, M.M., Meador, J.P., Myers, M.S., Reichert, W.L., and Stein, J.E. (2007a). The Effects of Polycyclic Aromatic Hydrocarbons in Fish from Puget Sound, Washington In The Toxicology of Fishes.

Johnson, L.L., Ylitalo, G.M., Arkoosh, M.R., Kagley, A.N., Stafford, C., Bolton, J.L., Buzitis, J., Anulacion, B.F., and Collier, T.K. (2007b). Contaminant exposure in outmigrant juvenile salmon from Pacific Northwest estuaries of the United States. Environ Monit Assess *124*, 167-194.

Keevin, T.M. (1998). A Review of Natural Resource Agency Recommendations for Mitigating the Impacts of Underwater Blasting. Reviews of Fisheries Science *6*, 32.

Kunkel, K.E., Stevens, L.E., Stevens, S.E., Sun, L., Janssen, E., Wuebbles, D., Redmond, K.T., and Dobson, J.G. (2013). Regional Climate Trends and Scenarios for the U.S. National Climate Assessment: Part 6. Climate of the Northwest U.S. In NOAA Technical Report (Washington, D.C.: National Oceanic and Atmospheric Administration, National Environmental Satellite, Data, and Information Service), pp. 83.

Laughlin, J. (2004). Underwater sound levels associated with construction of the SR 240 Bridge on teh Yakima River at Richland (Seattle, WA: Washington State Department of Transportation Office of Air Quality and Noise).

Lawson, P.W., Longerwell, E.A., Mantua, N.J., Francis, R.C., and Agostini, V.N. (2004). Environmental factors influencing freshwater survival and smolt production in Pacific Northwest coho salmon (Oncorhynchus kisutch). Canadian Journal of Fisheries and Aquatic Sciences *61*, 13.
Longmuir, C., and Lively, T. (2001). Bubble Curtain Systems for Use During Marine Pile Driving. (Vancouver, BC: Fraser river Pile and Dredge ltd).

Lyons, D.E., roby, D.D., and collis, K. (2007). Foraging ecology of Caspian Terns in the Columbia River estuary, USA. Waterbirds *28*, 11.

Mantua, N., and Hamlet, A. (2010). Climate change impacts on streamflow extremes and summertime stream temperature and their possible consequences for freshwater salmon habitat in Washington State. Climate Change *102(1)*, 187-223.

Mantua, N., Tohver, I., and Hamlet, A. (2009). Impacts of Climate Change on Key Aspects of Freshwater Salmon Habitat in Washington State. (University of Washington, Seattle, Washington: The Climate Impacts Group).

Martinelli, T.L., and Shively, R.S. (1997). Seasonal distribution, movement, and habitat associations of Northern squawfish in two lower Columbia River reservoirs. Regulated Rivers Research and Management *13*, 543.

McCabe, G.T., Emmett, R.L., Muir, W.D., and Blahm, T.H. (1986). Utilization of the Columbia River estuary by subyearling chinook salmon. Northwest Science *60*, 11.

McClure, M., Cooney, T., and Interior Columbia Technical Recovery Team (2005). Updated population delineation in the interior Columbia Basin. Memorandum to NMFS NW Regional Office, co-managers and other interested parties.

McElhany, P., Ruckelshaus, M.H., Ford, M.J., Wainwright, T.C., and Bjorkstedt, E.P. (2000). Viable salmonid populations and the recovery of evolutionarily significant units (U. S. Department of Commerce), pp. 156.

McMahon, T.T., and Hartman, G.F. (1989). Influence of cover complexity and current velocity on winter habitat use by juvenile coho salmon (Oncorhynchus kisutch). Canadian Journal of fisheries and Aquatic Sciences *46*, 6.

Meyer, J.L., Sale, M.J., Mulholland, P.J., and Poff, N.L. (1999). Impacts of climate change on aquatic ecosystem functioning and health. JAWRA Journal of the American Water Resources Association *35*, 13.

Mote, P.W. (2016). Perspectives on the cause of exceptionally low 2015 snowpack in the western United States. Geophysical Research letters *43*.

Mote, P.W., Abatzglou, J.T., and Kunkel, K.E. (2013). Climate: Variability and Change in the Past and the Future. (Washington D.C.: Island Press).

Mote, P.W., Snover, A.K., Capalbo, S., Eigenbrode, S.D., Glick, P., Littell, J., Rayomdi, R.R., and Reeder, W.S. (2014). Climate Change Impacts in the United States: The Third National Climate Assessment (U.S. Global Change Research Program).

Myers, J.M., busack, C., Rawding, D., Marshall, A.R., Teel, D.J., Doornik, D.M.V., and Maher, M.T. (2006). Historical population structure of Pacific salmonids in the Willamette River and lower Columbia River basins (U. S. Department of Commerce), pp. 311.

Newcombe, C.P., and Jensen, J.O.T. (1996). Channel Suspended Sediment and Fisheries: A Synthesis for Quantitative Assessment of Risk and Impact. North American Journal of Fisheries Management *16*, 27.

NMFS (2005). Assessment of NOAA Fisheries' critical habitat analytical review teams for 12 evolutionarily significant units of West Coast salmon and steelhead (Portland, Oregon: National Marine Fisheries Service, Protected Resources Division).

NMFS (2013a). ESA recovery plan for Lower Columbia River coho salmon, Lower Columbia River Chinook salmon, Columbia River chum salmon and Lower Columbia River steelhead. (Seattle, WA: National Marine Fisheries Service, Northwest Region).

NMFS (2013b). ESA recovery plan for lower Columbia River coho salmon, lower Columbia River Chinook salmon, Columbia River chum salmon, and Lower Columbia River steelhead, N.R. National Marine fisheries Service, ed. (Seattle, WA).

NMFS (2016). 5-Year Review: Summary and Evaluation of Upper Willamette River Steelhead, Upper Willamette River Chinook (Portland, OR: National Marine Fisheries Service, West Coast Region).

NOAA Fisheries (2011). Biennial report to Congress on the recovery program for threatened and endangered species October 1, 2008 – September 30, 2010, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, ed. (Washington, D.C.).

NWFSC (2015a). Status review update for Pacific salmon and steelhead listed under the Endangered Species Act: Pacific Northwest. (Northwest Fisheries Science Center).

NWFSC (2015b). Status review update for Pacific salmon and steelhead listed under the EndangeredSpecies Act: Pacific Northwest (Northwest Fisheries Science Center).

ODFW and NMFS (2011a). Upper Willamette River conservation and recovery plan for Chinook salmon and steelhead (Oregon Department of Fish and Wildlifeand National Marine Fisheries Service, Northwest Region).

ODFW and NMFS (2011b). Upper Willamette River conservation and recovery plan for Chinook salmon and steelhead, Oregon Department of Fish and Wildlife and National Marine Fisheries Service, Northwest Region, ed.

Oestman, R., Buehler, D., Reyff, J., and Rodkin, R. (2009). Technical Guidance for Assessment and Mitigation of the Hydroacoustic Effects of Pile Driving on Fish (Sacramento, CA: California Department of Transporation).

Petersen, J.H., and Gadomski, D.M. (1994). Light-mediated predation by northern squawfish on juvenile chinook salmon. Journal of Fish Biology *45*, 15.

Popper, A.N. (2003). Effects of Anthropogenic Sounds on Fishes. Fisheries *28*, 7.

Popper, A.N., and Hastings, M.C. (2009). The effects of anthropogenic sources of sound on fishes. Journal of fish Biology *75*, 34.

Pribyl, A.L., Vile, J.S., and Friesen, T.A. (2005). Population structure, movement, habitat use, and diet of resident piscivorous fishes in the lower Willamette River. In Biology, behavior, and resources of resident and anadromous fish in the lower Willamette River (Clackamas, OR: Oregon Department of Fish and Wildlife), pp. 45.

Raymondi, R.R., Cuhaciyan, J.E., Glick, P., Capalbo, S.M., Houston, L.L., Shafer, S.L., and Grah, O. (2013). Water Resources: Implications of Changes in Temperature and Precipitation. (Washington D.C.: Island Press).

Reeder, W.S., Ruggiero, P.R., Shafer, S.L., Snover, A.K., Houston, L.L., Glick, P., Newton, J.A., and Capalbo, S.M. (2013). Coasts: Complex Changes Affecting the Northwest's Diverse Shorelines.

Reyff, J.A. (2003). Underwater sound levels associated with construction of the Benicia-Martinez Bridge, acoustical evaluation of an unconfined air-bubble curtain system at Pier 13 (Sacramento, CA: State of California Department of Transportation), pp. 25.

Rodkin, R.B., and Reyff, J.A. (2007). Underwater Sound From Marine Pile Driving. . Bioacoustics *17*, 2.

Roegner, G.C., McNatt, R., Teel, D.J., and Bottom, D.L. (2012). Distribution, Size, and Origin of Juvenile Chinook Salmon in Shallow-Water Habitats of the Lower Columbia River and Estuary, 2002–2007. Marine and Coastal Fisheries *4*, 22.

Rondorf, D.W., Rutz, G.L., and Carrier, J.C. (2010). Minimizing Effects of Over-Water Docks on Federally Listed Fish Stocks in McNary Reservoir: A Literature Review for Criteria (Walla Walla, WA: U.S. Army Corps of Engineers), pp. 41.

Scheuerell, M.D., and Williams, J.G. (2005). Forecasting climate-induced changes in the survival of Snake River spring/summer Chinook salmon (Oncorhynchus tshawytscha). Fisheries Oceanography *14*, 9.

Stratus Consulting (2006). Creosote-Treated Wood In Aquatic Environments: Technical Review and Use Recommendations (Santa Rosa, California: Prepared for NOAA Fisheries Southwest Division).

Sunda, W.G., and Cai, W.J. (2012). Eutrophication induced CO2-acidification of subsurface coastal waters: interactive effects of temperature, salinity, and atmospheric p CO2. Environmental Science & Technology *46*, 8.

Tabor, R.A., Shively, R.S., and Poe, T.P. (1993). Predation on Juvenile Salmonids by Smallmouth Bass and Northern Squawfish in the Columbia River near Richland, Washington. North American Journal of Fisheries Management *13*, 7.

Tague, C.L., Choate, J.S., and Grant, G. (2013). Parameterizing sub-surface drainage with geology to improve modeling streamflow responses to climate in data limited environments. Hydrology and Earth System Sciences *17*, 341-354.

Takata, T.T. (2011). Oregon Lower Columbia River fall and winter Chinook spawning ground surveys 1952-2010 (Oregon Department of Fish and Wildlife.), pp. 22.

Tillmann, P., and Siemann, D. (2011). Climate Change Effects and Adaptation Approaches in Marine and Coastal Ecosystems of the North Pacific Landscape Conservation Cooperative Region (National Wildlife Federation).

USDC (2014a). Endangered and threatened wildlife: Final rule to revise the Code of Federal Regulations for species under thejurisdiction of theNational Marine Fisheries Service (U. S. Department of Commerce), pp. 20802-20817.

USDC (2014b). Endangered and threatened wildlife; Final rule to revise the Code of Federal Regulations for species under the jurisdiction of the National Marine Fisheries Service. US Department of Commerce Federal Register *79*, 20802-20817.

Wainwright, T.C., and Weitkamp, L.A. (2013). Effects of climate change on Oregon Coast coho salmon: habitat and life-cycle interactions. Northwest Science *87*, 23.

Weitkamp, L.A., Bentley, P.J., and Litz, M.N. (2012). Seasonal and interannual variation in juvenile salmonids and associated fish assemblage in open waters of the lower Columbia River estuary, USA. National Marine Fisheries Service Fishery Bulletin *110*, 24.

Weston Solutions (2006). Jimmycomelately Piling Removal Monitoring Project (Port Gamble, WA: Weston Solutions).

Williams, J.G., smith, S.G., Zabel, R.W., Muir, W.D., Scheuerell, M.D., Sanford, B.P., Marsh, D.M., McNatt, R.A., and Achord, S. (2005). Effects of the Federal Columbia River Power System on Salmon Populations (U.S. Dept. Commer), pp. 150.

Winder, M., and Schindler, D.E. (2004). Climate change uncouples trophic interactions in an aquatic ecosystem.

Wissmar, R.C., smith, J.E., McIntosh, B.A., Li, H.W., reeves, G.H., and Sedell, J.R. (1994). Ecological health of river basins in forested regions of eastern Washington and Oregon (Portland, Oregon: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station).

Wursig, B., Greene, C.R., and Jefferson, T.A. (2000). Development of an air bubble curtain to reduce underwater noise of percussive piling. Marine Environmental Research *49*, 14.

Yelverton, J.T., Richmond, D.R., Hicks, W., Saunders, K., and Saunders, E.R. (1975). The Relationship Between Fish Size and their Response to Underwater Blast (Washington, DC: Defense Nuclear Agency).

Zabel, R.W., Scheuerell, M.D., McClure, M.M., and Williams, J.G. (2006). The interplay between climate variability and density dependence in the population viability of Chinook salmon. Conseration Biology *20*, 10.

6. APPENDIX 1

To estimate the likelihood of exposure to sound pressure waves, NMFS used the steady state solution; $\therefore \frac{C}{C_{IN}} = \frac{4\beta_D exp\left(0.5\frac{v_x L}{\mathcal{D}_d}\right)}{(1+\beta_D)^2 exp\left(0.5\beta_D\frac{v_x L}{\mathcal{D}_d}\right)-(1-\beta_D)^2 exp\left(0.5\beta_D\frac{v_x L}{\mathcal{D}_d}\right)}, \therefore \beta_D = \left(1+4\frac{kL}{v_x}\frac{\mathcal{D}_d}{v_x L}\right)^{0.5}$, to the advection-dispersion equation: $\mathcal{D}_d \frac{\partial^2 C}{\partial x^2} - v_x \frac{\partial C}{\partial x} + kC = 0$ with a continuous source term to estimate the density of subyearling Chinook in the vicinity of the NWA dock impact pile driving. The Fish Passage Center (FPC, http://www.fpc.org/) reported an average of 85 subyearling Chinook per day passing Bonneville Dam in September and October from 2012 to 2016. NMFS guessed that half of these fish would migrate along the Washington shoreline and pass the NWA dock[4] and then multiplied by 3 to include subyearlings from the Lower Columbia River tributaries. Zabel and Anderson, (1997) report the range of advection and dispersion coefficients for subyearling Chinook in the Snake River. The values assigned to the steady state solution parameters are summarized in Table A1.

Table A1. Advection diffusion solution parameters

Source	C_{in}	120 fish per day (FPC)
Advection coefficient	v_x	5 kilometers/day (Zabel and Anderson, 1997)
Length from Bonneville to Longview	L	125 kilometers
Dispersion coefficient	D_d	100 (Zabel and Anderson, 1997)
Die off rate	k	.01 (set small to minimize influence)

[4] Roegner captured 56 fingerlings between September and November at the Cowlitz River Tributary confluence. 50 percent were natural fish and 50 percent were hatchery fish. 94 percent were West Cascade tributary fall Chinook.