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-2022-00159

September 26, 2022

William Abadie
Department of the Army
U.S. Army Corps of Engineers, Portland District
P.O. Box 2946
Portland, Oregon 97208-2946

Re: Endangered Species Act Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response for the American Cruise Lines 17th Street Dock Dolphin Replacement, Astoria, Oregon (HUC 170800060500)

Dear Mr. Abadie:

This letter responds to your January 24, 2022, request for initiation of consultation with the National Marine Fisheries Service (NMFS) pursuant to Section 7 of the Endangered Species Act (ESA) for the subject action. It also responds to your August 17, 2022 email supplementing the consultation with an additional request for our concurrence with your determination that the proposed action is not likely to adversely affect (NLAA) Southern Resident Killer Whales (SRKW) or their designated critical habitat. Your request qualified for our expedited review and analysis because it met our screening criteria and contained all required information on, and analysis of, your proposed action and its potential effects to listed species and designated critical habitat.

On July 5, 2022, the United States District Court for the Northern District of California issued an order vacating the 2019 regulations adopting changes to 50 CFR part 402 (84 FR 44976, August 27, 2019). This consultation was initiated when the 2019 regulations were still in effect. As reflected in this document, we are now applying the Section 7 regulations that governed prior to adoption of the 2019 regulations. For purposes of this consultation, we considered whether the substantive analysis and its conclusions regarding the effects of the proposed actions articulated in the biological opinion and incidental take statement would be any different under the 2019 regulations. We have determined that our analysis and conclusions would not be any different.

We reviewed the U.S. Army Corps of Engineers (USACE) consultation request and related initiation package. Where relevant, we have adopted the information and analyses you have provided and/or referenced but only after our independent, science-based evaluation confirmed they meet our regulatory and scientific standards.

We adopt by reference here:

- sections 1.3 and 1.4 of the biological assessment (BA) for the proposed action and best management practices (BMP) respectively, and Appendix B, which describe pile driving monitoring, soft start, and stop work protocols. By email of 8/17/22, the USACE indicates those protocols will be extended to monitor for humpback whales and Southern Resident Killer Whales as well, to ensure that pile driving noise exposure will not reach harmful levels.
- section 1.5 for the action area,
- sections 2.4 through section 2.7 for the status of salmon and steelhead species affected by the proposed action,
- section 2.8 for the status of eulachon affected by the proposed action and
- section 2.9 for the status of green sturgeon affected by the proposed action.

We adopt by reference here:

- sections 3.1 and 3.2 for the environmental baseline of the action area,
- section 4.1 for the effects of the proposed action on ESA-listed species and their critical habitat and
- section 4.2 for the interrelated and interdependent effects of the proposed action on ESA-listed species and their critical habitat.

We note where we have supplemented information in the BA with our own data and analysis. The BA will be included in the administrative record for this consultation and we will send it to readers of the biological opinion as an email replay attachment to requests sent to Tom.Hausmann@noaa.gov.

Per BA section 1.3 on pages 1 and 2, American Cruise Lines proposes to remove seven steel mooring dolphins in the Columbia River estuary adjacent to Astoria, Washington. The seven dolphins are made of a total of eighteen 10 or 12-inch wide H piles and three 12-inch diameter steel pipe piles. These piles would be removed with a vibratory pile driver. American Cruise Lines proposes to install five 36-inch diameter steel pipe monopile dolphins with floating fender units and mooring rings. Each new pile would be installed with up to 45 minutes of vibratory pile driving and up to 2000 impact hammer blows. The in water work window is November 1 to February 28 and American Cruise Lines expects in water work to last up to 19 days.

BMPs and conservation measures to reduce potential effects are summarized in BA section 1.4 starting on page 3. BMPs address and minimize all of the incidental take pathways to ESA-listed salmon, steelhead, eulachon and green sturgeon, including soft start procedures for both vibratory and impact pile driving and a bubble curtain during impact pile driving to minimize exposure to noise and sound pressure waves. BMPs also include procedures to retrieve debris during pile removal and standard practices to minimize the risk of and rapidly clean up a fuel or hazardous material spill,

We examined the status of each species that would be adversely affected by the proposed action to inform the description of the species' "reproduction, numbers, or distribution" as described in 50 CFR 402.02. We also examined the condition of critical habitat throughout the designated area and discuss the function of the physical or biological features essential to the conservation of the species that create the conservation value of that habitat.

The BA summarizes the status of five Chinook salmon ESUs (Lower Columbia River (LCR), Upper Columbia River (UCR), Upper Willamette River (UWR), Snake River (SR) spring/summer and SR fall) and their critical habitat in section 2.4 starting on page 11. The BA describes the migration windows of each ESU and notes that some juvenile LCR, UWR, and SR fall Chinook salmon rear in the action area all year. The BA references the life-history migration timing windows in biological opinion NWR 2011-02731 (City of Astoria 17th Street Dock Replacement). We add here that our more current understanding of migration timing through the estuary is that adult UWR Chinook migration through the estuary may start as early as January and overlap the in water work window.

We supplement the BA's presentation of status of species and critical habitat with information summarized in the following two tables. Table 1, below provides a summary of listing and recovery plan information, status summaries and limiting factors for the species addressed in this opinion. More information can be found in recovery plans and status reviews for these species. Acronyms appearing in the table include DPS (Distinct Population Segment), ESU (Evolutionarily Significant Unit), ICTRT (Interior Columbia Technical Recovery Team), MPG (Multiple Population Grouping), NWFSC (Northwest Fisheries Science Center), TRT (Technical Recovery Team), and VSP (Viable Salmonid Population).
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Table 1 Listing classification and date, recovery plan reference, most recent status review, status summary, and limiting factors for each species considered in this opinion.

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
Lower Columbia River Chinook salmon	Threatened 6/28/05	NMFS 2013	NMFS 2016; Ford 2022	This ESU comprises 32 independent populations. Relative to baseline VSP levels identified in the recovery plan (Dornbusch 2013), there has been an overall improvement in the status of a number of fall-run populations although most are still far from the recovery plan goals; Spring-run Chinook salmon populations in this ESU are generally unchanged; most of the populations are at a "high" or "very high" risk due to low abundances and the high proportion of hatchery-origin fish spawning naturally. Many of the populations in this ESU remain at "high risk," with low natural-origin abundance levels. Overall, we conclude that the viability of the Lower Columbia River Chinook salmon ESU has increased somewhat since 2016, although the ESU remains at "moderate" risk of extinction	• Reduced access to spawning and rearing habitat • Hatchery-related effects • Harvest-related effects on fall Chinook salmon • An altered flow regime and Columbia River plume • Reduced access to off-channel rearing habitat • Reduced productivity resulting from sediment and nutrient-related changes in the estuary • Contaminant
Upper Columbia River spring-run Chinook salmon	Endangered 6/28/05	Upper Columbia Salmon Recovery Board 2007	NMFS 2016; Ford 2022	This ESU comprises four independent populations. Current estimates of natural-origin spawner abundance decreased substantially relative to the levels observed in the prior review for all three extant populations. Productivities also continued to be very low, and both abundance and productivity remained well below the viable thresholds called for in the Upper Columbia Salmon Recovery Plan for all three populations. Based on the information available for this review, the Upper Columbia River spring-run Chinook salmon ESU remains at high risk, with viability largely unchanged since 2016. .	• Effects related to hydropower system in the mainstem Columbia River • Degraded freshwater habitat • Degraded estuarine and nearshore marine habitat • Hatchery-related effects • Persistence of non-native (exotic) fish species • Harvest in Columbia River fisheries
Snake River spring/summer-run Chinook salmon	Threatened 6/28/05	NMFS 2017a	NMFS 2016; Ford 2022	This ESU comprises 28 extant and four extirpated populations. There have been improvements in abundance/productivity in several populations relative to the time of listing,	• Degraded freshwater habitat • Effects related to the hydropower system in the mainstem Columbia River, • Altered flows and degraded water quality

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
				but the majority of populations experienced sharp declines in abundance in the recent five-year period Overall, at this time we conclude that the Snake River spring/ summer-run Chinook salmon ESU continues to be at moderate-to-high risk.	• Harvest-related effects • Predation
Upper Willamette River Chinook salmon	Threatened 6/28/05	NMFS 2011	NMFS 2016; Ford 2022	This ESU comprises seven populations. Abundance levels for all but Clackamas River DIP remain well below their recovery goals. Overall, there has likely been a declining trend in the viability of the Upper Willamette River Chinook salmon ESU since the last review. The magnitude of this change is not sufficient to suggest a change in risk category, however, so the Upper Willamette River Chinook salmon ESU remains at "moderate" risk of extinction.	• Degraded freshwater habitat • Degraded water quality • Increased disease incidence • Altered stream flows • Reduced access to spawning and rearing habitats • Altered food web due to reduced inputs of microdetritus • Predation by native and non-native species, including hatchery fish • Competition related to introduced salmon and steelhead • Altered population traits due to fisheries and bycatch
Snake River fall-run Chinook salmon	Threatened 6/28/05	NMFS 2017b	NMFS 2016; Ford 2022	This ESU has one extant population The single extant population in the ESU is currently meeting the criteria for a rating of "viable" developed by the ICTRT, but the ESU as a whole is not meeting the recovery goals described in the recovery plan for the species, which require the single population to be "highly viable with high certainty" and/or will require reintroduction of a viable population above the Hells Canyon Complex (NMFS 2017b). The Snake River fall-run Chinook salmon ESU therefore is considered to be at a moderate-to-low risk of extinction.	• Degraded floodplain connectivity and function • Harvest-related effects • Loss of access to historical habitat above Hells Canyon and other Snake River dams • Impacts from mainstem Columbia River and Snake River hydropower systems • Hatchery-related effects • Degraded estuarine and nearshore habitat.
Columbia River chum salmon	Threatened 6/28/05	NMFS 2013	NMFS 2016; Ford 2022	This species has 17 populations divided into 3 MPGs. 3 populations exceed the recovery goals established in the recovery plan (Dornbusch 2013). The remaining populations have unknown abundances. Abundances for these populations are assumed to be at or near zero. The viability of this ESU is relatively unchanged since the	• Degraded estuarine and nearshore marine habitat • Degraded freshwater habitat • Degraded stream flow as a result of hydropower and water supply operations • Reduced water quality

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
				last review (moderate to high risk), and the improvements in some populations do not warrant a change in risk category, especially given the uncertainty regarding climatic effects in the near future.	• Current or potential predation • An altered flow regime and Columbia River plume • Reduced access to off-channel rearing habitat in the lower Columbia River • Reduced productivity resulting from sediment and nutrient-related changes in the estuary • Juvenile fish wake strandings • Contaminants
Lower Columbia River coho salmon	Threatened 6/28/05	NMFS 2013	NMFS 2016; Ford 2022	Of the 24 populations that make up this ESUOnly six of the 23 populations for which we have data appear to be above their recovery goals. Overall abundance trends for the Lower Columbia River coho salmon ESU are generally negative. Natural spawner and total abundances have decreased in almost all DIPs, and Coastal and Gorge MPG populations are all at low levels, with significant numbers of hatchery-origin coho salmon on the spawning grounds. Improvements in spatial structure and diversity have been slight, and overshadowed by declines in abundance and productivity. For individual populations, the risk of extinction spans the full range, from “low” to “very high.” Overall, the Lower Columbia River coho salmon ESU remains at “moderate” risk, and viability is largely unchanged since 2016.	• Degraded estuarine and near-shore marine habitat • Fish passage barriers • Degraded freshwater habitat: Hatchery-related effects • Harvest-related effects • An altered flow regime and Columbia River plume • Reduced access to off-channel rearing habitat in the lower Columbia River • Reduced productivity resulting from sediment and nutrient-related changes in the estuary • Juvenile fish wake strandings • Contaminants
Snake River sockeye salmon	Endangered 6/28/05	NMFS 2015	NMFS 2016; Ford 2022	This single population ESU is at remains at “extremely high risk,” although there has been substantial progress on the first phase of the proposed recovery approach—developing a hatchery-based program to amplify and conserve the stock to facilitate reintroductions. Current climate change modeling supports the “extremely high risk” rating with the potential for extirpation in the near future (Crozier et al. 2020). The viability of the Snake River sockeye salmon ESU therefore has likely declined since	• Effects related to the hydropower system in the mainstem Columbia River • Reduced water quality and elevated temperatures in the Salmon River • Water quantity • Predation

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
				the time of the prior review, and the extinction risk category remains "high."	
Upper Columbia River steelhead	Threatened 1/5/06	Upper Columbia Salmon Recovery Board 2007	NMFS 2016; Ford 2022	This DPS comprises four independent populations. The most recent estimates (five year geometric mean) of total and natural-origin spawner abundance have declined since the last report, largely erasing gains observed over the past two decades for all four populations (Figure 12, Table 6). Recent declines are persistent and large enough to result in small, but negative 15-year trends in abundance for all four populations. The overall Upper Columbia River steelhead DPS viability remains largely unchanged from the prior review, and the DPS is at high risk driven by low abundance and productivity relative to viability objectives and diversity concerns.	• Adverse effects related to the mainstem Columbia River hydropower system • Impaired tributary fish passage • Degraded floodplain connectivity and function, channel structure and complexity, riparian areas, large woody debris recruitment, stream flow, and water quality • Hatchery-related effects • Predation and competition • Harvest-related effects
Lower Columbia River steelhead	Threatened 1/5/06	NMFS 2013	NMFS 2016; Ford 2022	This DPS comprises 23 historical populations, 17 winter-run populations and 6 summer-run populations. 10 are nominally at or above the goals set in the recovery plan (Dornbusch 2013); however, it should be noted that many of these abundance estimates do not distinguish between natural- and hatchery- origin spawners. The majority of winter-run steelhead DIPs in this DPS continue to persist at low abundance levels (hundreds of fish), with the exception of the Clackamas and Sandy River DIPs, which have abundances in the low 1,000s. Although the five-year geometric abundance means are near recovery plan goals for many populations, the recent trends are negative. Overall, the Lower Columbia River steelhead DPS is therefore considered to be at "moderate" risk.,	• Degraded estuarine and nearshore marine habitat • Degraded freshwater habitat • Reduced access to spawning and rearing habitat • Avian and marine mammal predation • Hatchery-related effects • An altered flow regime and Columbia River plume • Reduced access to off-channel rearing habitat in the lower Columbia River • Reduced productivity resulting from sediment and nutrient-related changes in the estuary • Juvenile fish wake strandings • Contaminants
Upper Willamette River steelhead	Threatened 1/5/06	NMFS 2011	NMFS 2016; Ford 2022	This DPS has four demographically independent populations. Populations in this DPS have experienced long-term declines in spawner abundance. Although the recent magnitude of these declines is relatively moderate, continued	• Degraded freshwater habitat • Degraded water quality • Increased disease incidence • Altered stream flows

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				declines would be a cause for concern. In the absence of substantial changes in accessibility to high-quality habitat, the DPS will remain at “moderate-to-high” risk. Overall, the Upper Willamette River steelhead DPS is therefore at “moderate-to-high” risk, with a declining viability trend.	• Reduced access to spawning and rearing habitats due to impaired passage at dams • Altered food web due to changes in inputs of microdetritus • Predation by native and non-native species, including hatchery fish and pinnipeds • Competition related to introduced salmon and steelhead • Altered population traits due to interbreeding with hatchery origin fish
Middle Columbia River steelhead	Threatened 1/5/06	NMFS 2009b	NMFS 2016; Ford 2022	This DPS comprises 17 extant populations. Recent (five-year) returns are declining across all populations, the declines are from relatively high returns in the previous five-to-ten year interval, so the longer-term risk metrics that are meant to buffer against short-period changes in abundance and productivity remain unchanged. The Middle Columbia River steelhead DPS does not currently meet the viability criteria described in the Middle Columbia River steelhead recovery plan.	• Degraded freshwater habitat • Mainstem Columbia River hydropower-related impacts • Degraded estuarine and nearshore marine habitat • Hatchery-related effects • Harvest-related effects • Effects of predation, competition, and disease
Snake River basin steelhead	Threatened 1/5/06	NMFS 2017a	NMFS 2016; Ford 2022	This DPS comprises 24 populations. Based on the updated viability information available for this review, all five MPGs are not meeting the specific objectives in the draft recovery plan, and the viability of many individual populations remains uncertain. Of particular note, the updated, population-level abundance estimates have made very clear the recent (last five years) sharp declines that are extremely worrisome, were they to continue.	• Adverse effects related to the mainstem Columbia River hydropower system • Impaired tributary fish passage • Degraded freshwater habitat • Increased water temperature • Harvest-related effects, particularly for B-run steelhead • Predation • Genetic diversity effects from out-of-population hatchery releases
Southern DPS of green sturgeon	Threatened 4/7/06	NMFS 2018	NMFS 2015c	The Sacramento River contains the only known green sturgeon spawning population in this DPS. The current estimate of spawning adult abundance is between 824-1,872 individuals. Telemetry data and genetic analyses suggest that Southern DPS green sturgeon generally occur from Graves Harbor, Alaska to Monterey Bay, California and, within this range, most frequently occur in coastal waters of Washington, Oregon,	• Reduction of its spawning area to a single known population • Lack of water quantity • Poor water quality • Poaching

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
				and Vancouver Island and near San Francisco and Monterey bays. Within the nearshore marine environment, tagging and fisheries data indicate that Northern and Southern DPS green sturgeon prefer marine waters of less than a depth of 110 meters.	
Southern DPS of eulachon	Threatened 3/18/10	NMFS 2017c	Gustafson et al. 2016	The Southern DPS of eulachon includes all naturally-spawned populations that occur in rivers south of the Nass River in British Columbia to the Mad River in California. Sub populations for this species include the Fraser River, Columbia River, British Columbia and the Klamath River. In the early 1990s, there was an abrupt decline in the abundance of eulachon returning to the Columbia River. Despite a brief period of improved returns in 2001-2003, the returns and associated commercial landings eventually declined to the low levels observed in the mid-1990s. Although eulachon abundance in monitored rivers has generally improved, especially in the 2013-2015 return years, recent poor ocean conditions and the likelihood that these conditions will persist into the near future suggest that population declines may be widespread in the upcoming return years	• Changes in ocean conditions due to climate change, particularly in the southern portion of the species' range where ocean warming trends may be the most pronounced and may alter prey, spawning, and rearing success. • Climate-induced change to freshwater habitats • Bycatch of eulachon in commercial fisheries • Adverse effects related to dams and water diversions • Water quality, • Shoreline construction • Over harvest • Predation
Southern resident killer whale	Endangered 11/18/05	NMFS 2008	NWFSC 2021	The Southern Resident killer whale DPS is composed of a single population that ranges as far south as central California and as far north as southeast Alaska. While some of the downlisting and delisting criteria have been met, the biological downlisting and delisting 63 criteria, including sustained growth over 14 and 28 years, respectively, have not been met. The SRKW DPS has not grown; the overall status of the population is not consistent with a healthy, recovered population. Considering the status and continuing threats, the Southern Resident killer whales remain in danger of extinction.	• Quantity and quality of prey • Exposure to toxic chemicals • Disturbance from sound and vessels • Risk from oil spills

Central America DPS humpback whale	Endangered 9/8/16	NMFS 1991	SWFSC 2015;	Whales from this breeding ground feed almost exclusively offshore of California and Oregon in the eastern Pacific, with only a few individuals identified at the northern Washington-southern British Columbia feeding grounds. The CAM DPS is listed as endangered and has been most recently estimated to include 783 whales (CV = 0.170, Wade 2017) with unknown population trend.	Entanglement in fishing gear and vessel collisions, in particular, were identified as the most significant threats to this DPS in the 2016 final listing rule (81 FR 62260, September 8, 2016).
Mexico DPS humpback whale	Threatened 9/8/16	NMFS 1991	SWFSC 2015;	This DPS has also been documented within the Salish Sea (Calambokidis et al. 2017). Sightings of humpback whales in general have increased dramatically in the Salish Sea from 1995 to 2015, and at least 11 whales from this DPS have been matched to those sighted within this area (Calambokidis et al. 2017). This DPS was most recently estimated to have an abundance of 2,806 whales	Entanglement in fishing gear, especially off the coasts of Washington, Oregon, and California, was identified as the primary threat to this DPS.

Table 2. Critical habitat, designation date, federal register citation, and status summary for critical habitat considered in this opinion

Species	Designation Date and Federal Register Citation	Critical Habitat Status Summary
Lower Columbia River Chinook salmon	9/02/05 70 FR 52630	Critical habitat encompasses 10 subbasins in Oregon and Washington containing 47 occupied watersheds, as well as the lower Columbia River rearing/migration corridor. Most HUC5 watersheds with PCEs for salmon are in fair-to-poor or fair-to-good condition (NMFS 2005). However, most of these watersheds have some, or high potential for improvement. We rated conservation value of HUC5 watersheds as high for 30 watersheds, medium for 13 watersheds, and low for four watersheds.
Upper Columbia River spring-run Chinook salmon	9/02/05 70 FR 52630	Critical habitat encompasses four subbasins in Washington containing 15 occupied watersheds, as well as the Columbia River rearing/migration corridor. Most HUC5 watersheds with PCEs for salmon are in fair-to-poor or fair-to-good condition. However, most of these watersheds have some, or high, potential for improvement. We rated conservation value of HUC5 watersheds as high for 10 watersheds, and medium for five watersheds. Migratory habitat quality in this area has been severely affected by the development and operation of the dams and reservoirs of the Federal Columbia River Power System.
Snake River spring/summer-run Chinook salmon	10/25/99 64 FR 57399	Critical habitat consists of river reaches of the Columbia, Snake, and Salmon rivers, and all tributaries of the Snake and Salmon rivers (except the Clearwater River) presently or historically accessible to this ESU (except reaches above impassable natural falls and Hells Canyon Dam). Habitat quality in tributary streams varies from excellent in wilderness and roadless areas, to poor in areas subject to heavy agricultural and urban development (Wissmar et al. 1994). Reduced summer stream flows, impaired water quality, and reduced habitat complexity are common problems. Migratory habitat quality in this area has been severely affected by the development and operation of the dams and reservoirs of the Federal Columbia River Power System.

Species	Designation Date and Federal Register Citation	Critical Habitat Status Summary
Upper Willamette River Chinook salmon	9/02/05 70 FR 52630	Critical habitat encompasses 10 subbasins in Oregon containing 56 occupied watersheds, as well as the lower Willamette/Columbia River rearing/migration corridor. Most HUC5 watersheds with PCEs for salmon are in fair-to-poor or fair-to-good condition. However, most of these watersheds have some, or high, potential for improvement. Watersheds are in good to excellent condition with no potential for improvement only in the upper McKenzie River and its tributaries (NMFS 2005). We rated conservation value of HUC5 watersheds as high for 22 watersheds, medium for 16 watersheds, and low for 18 watersheds.
Snake River fall-run Chinook salmon	10/25/99 64 FR 57399	Critical habitat consists of river reaches of the Columbia, Snake, and Salmon rivers, and all tributaries of the Snake and Salmon rivers presently or historically accessible to this ESU (except reaches above impassable natural falls, and Dworshak and Hells Canyon dams). Habitat quality in tributary streams varies from excellent in wilderness and roadless areas, to poor in areas subject to heavy agricultural and urban development (Wissmar et al. 1994). Reduced summer stream flows, impaired water quality, and reduced habitat complexity are common problems. Migratory habitat quality in this area has been severely affected by the development and operation of the dams and reservoirs of the Federal Columbia River Power System.
Columbia River chum salmon	9/02/05 70 FR 52630	Critical habitat encompasses six subbasins in Oregon and Washington containing 19 occupied watersheds, as well as the lower Columbia River rearing/migration corridor. Most HUC5 watersheds with PCEs for salmon are in fair-to-poor or fair-to-good condition (NMFS 2005). However, most of these watersheds have some or a high potential for improvement. We rated conservation value of HUC5 watersheds as high for 16 watersheds, and medium for three watersheds.
Lower Columbia River coho salmon	2/24/16 81 FR 9252	Critical habitat encompasses 10 subbasins in Oregon and Washington containing 55 occupied watersheds, as well as the lower Columbia River and estuary rearing/migration corridor. Most HUC5 watersheds with PCEs for salmon are in fair-to-poor or fair-to-good condition (NMFS 2005). However, most of these watersheds have some or a high potential for improvement. We rated conservation value of HUC5 watersheds as high for 34 watersheds, medium for 18 watersheds, and low for three watersheds.
Snake River sockeye salmon	10/25/99 64 FR 57399	Critical habitat consists of river reaches of the Columbia, Snake, and Salmon rivers; Alturas Lake Creek; Valley Creek; and Stanley, Redfish, Yellow Belly, Pettit and Alturas lakes (including their inlet and outlet creeks). Water quality in all five lakes generally is adequate for juvenile sockeye salmon, although zooplankton numbers vary considerably. Some reaches of the Salmon River and tributaries exhibit temporary elevated water temperatures and sediment loads that could restrict sockeye salmon production and survival (NMFS 2015b). Migratory habitat quality in this area has been severely affected by the development and operation of the dams and reservoirs of the Federal Columbia River Power System.
Upper Columbia River steelhead	9/02/05 70 FR 52630	Critical habitat encompasses 10 subbasins in Washington containing 31 occupied watersheds, as well as the Columbia River rearing/migration corridor. Most HUC5 watersheds with PCEs for salmon are in fair-to-poor or fair-to-good condition (NMFS 2005). However, most of these watersheds have some or a high

Species	Designation Date and Federal Register Citation	Critical Habitat Status Summary
		potential for improvement. We rated conservation value of HUC5 watersheds as high for 20 watersheds, medium for eight watersheds, and low for three watersheds.
Lower Columbia River steelhead	9/02/05 70 FR 52630	Critical habitat encompasses nine subbasins in Oregon and Washington containing 41 occupied watersheds, as well as the lower Columbia River rearing/migration corridor. Most HUC5 watersheds with PCEs for salmon are in fair-to-poor or fair-to-good condition (NMFS 2005). However, most of these watersheds have some or a high potential for improvement. We rated conservation value of HUC5 watersheds as high for 28 watersheds, medium for 11 watersheds, and low for two watersheds.
Upper Willamette River steelhead	9/02/05 70 FR 52630	Critical habitat encompasses seven subbasins in Oregon containing 34 occupied watersheds, as well as the lower Willamette/Columbia River rearing/migration corridor. Most HUC5 watersheds with PCEs for salmon are in fair-to-poor or fair-to-good condition (NMFS 2005). However, most of these watersheds have some or a high potential for improvement. Watersheds are in good to excellent condition with no potential for improvement only in the upper McKenzie River and its tributaries (NMFS 2005). We rated conservation value of HUC5 watersheds as high for 25 watersheds, medium for 6 watersheds, and low for 3 watersheds.
Middle Columbia River steelhead	9/02/05 70 FR 52630	Critical habitat encompasses 15 subbasins in Oregon and Washington containing 111 occupied watersheds, as well as the Columbia River rearing/migration corridor. Most HUC5 watersheds with PCEs for salmon are in fair-to-poor or fair-to-good condition (NMFS 2005). However, most of these watersheds have some or a high potential for improvement. We rated conservation value of occupied HUC5 watersheds as high for 80 watersheds, medium for 24 watersheds, and low for 9 watersheds.
Snake River basin steelhead	9/02/05 70 FR 52630	Critical habitat encompasses 25 subbasins in Oregon, Washington, and Idaho. Habitat quality in tributary streams varies from excellent in wilderness and roadless areas, to poor in areas subject to heavy agricultural and urban development (Wissmar et al. 1994). Reduced summer stream flows, impaired water quality, and reduced habitat complexity are common problems. Migratory habitat quality in this area has been severely affected by the development and operation of the dams and reservoirs of the Federal Columbia River Power System.
Southern DPS of green sturgeon	10/09/09 74 FR 52300	Critical habitat has been designated in coastal U.S. marine waters within 60 fathoms depth from Monterey Bay, California (including Monterey Bay), north to Cape Flattery, Washington, including the Strait of Juan de Fuca, Washington, to its United States boundary; the Sacramento River, lower Feather River, and lower Yuba River in California; the Sacramento-San Joaquin Delta and Suisun, San Pablo, and San Francisco bays in California; tidally influenced areas of the Columbia River estuary from the mouth upstream to river mile 46; and certain coastal bays and estuaries in California (Humboldt Bay), Oregon (Coos Bay, Winchester Bay, Yaquina Bay, and Nehalem Bay), and Washington (Willapa Bay and Grays Harbor), including, but not limited to, areas upstream to the head of tide in various streams that drain into the bays. Several activities threaten the PBFs in coastal bays and estuaries and need special management considerations or protection. The application of pesticides, activities that disturb bottom substrates/

Species	Designation Date and Federal Register Citation	Critical Habitat Status Summary
		adversely affect prey resources/ degrade water quality through re-suspension of contaminated sediments, commercial shipping and activities that discharge contaminants and result in bioaccumulation of contaminants in green sturgeon; disposal of dredged materials that bury prey resources; and bottom trawl fisheries that disturb the bottom/prey resources for green sturgeon.
Southern DPS of eulachon	10/20/11 76 FR 65324	Critical habitat for eulachon includes portions of 16 rivers and streams in California, Oregon, and Washington. All of these areas are designated as migration and spawning habitat for this species. In Oregon, we designated 24.2 miles of the lower Umpqua River, 12.4 miles of the lower Sandy River, and 0.2 miles of Tenmile Creek. We also designated the mainstem Columbia River from the mouth to the base of Bonneville Dam, a distance of 143.2 miles. Dams and water diversions are moderate threats to eulachon in the Columbia and Klamath rivers where hydropower generation and flood control are major activities. Degraded water quality is common in some areas occupied by southern DPS eulachon. In the Columbia and Klamath river basins, large-scale impoundment of water has increased winter water temperatures, potentially altering the water temperature during eulachon spawning periods. Numerous chemical contaminants are also present in spawning rivers, but the exact effect these compounds have on spawning and egg development is unknown. Dredging is a low to moderate threat to eulachon in the Columbia River. Dredging during eulachon spawning would be particularly detrimental.
Southern resident killer whale	08/02/21 86 FR 41668	Critical habitat includes approximately 2,560 square miles of marine inland waters of Washington: 1) the Summer Core Area in Haro Strait and waters around the San Juan Islands; 2) Puget Sound; and 3) the Strait of Juan de Fuca. Six additional areas include 15,910 square miles of marine waters between the 20-feet (ft) (6.1-meter (m)) depth contour and the 656.2-ft (200-m) depth contour from the U.S. international border with Canada south to Point Sur, California. We have excluded the Quinault Range Site. Based on the natural history of the Southern Residents and their habitat needs, NMFS identified three PCEs, or physical or biological features, essential for the conservation of Southern Residents: 1) Water quality to support growth and development; 2) prey species of sufficient quantity, quality, and availability to support individual growth, reproduction and development, as well as overall population growth; and 3) passage conditions to allow for migration, resting, and foraging Water quality in Puget Sound, in general, is degraded. Some pollutants in Puget Sound persist and build up in marine organisms including Southern Residents and their prey resources, despite bans in the 1970s of some harmful substances and cleanup efforts. The primary concern for direct effects on whales from water quality is oil spills, although oil spills can also have long-lasting impacts on other habitat features In regards to passage, human activities can interfere with movements of the whales and impact their passage. In particular, vessels may present obstacles to whales' passage, causing the whales to swim further and change direction more often, which can increase energy expenditure for whales and impacts foraging behavior. Reduced prey abundance, particularly Chinook salmon, is also a concern for critical habitat.

Species	Designation Date and Federal Register Citation	Critical Habitat Status Summary
Central America DPS Humpback Whales	4/21/2021 86 FR21082	Specific areas designated as occupied critical habitat for the Central America DPS of humpback whales contain approximately 48,521 nmi^2 of marine habitat in the North Pacific Ocean within the portions of the California Current Ecosystem off the coasts of Washington, Oregon, and California. The nearshore boundary is defined by the 50-m isobath, and the offshore boundary is defined by the 1,200-m isobath relative to MLLW. The Columbia River Area was rated with medium/low conservation value. The PBF for this species is prey species of sufficient quality, abundance, and accessibility to support feeding and population growth.
Mexico DPS Humpback Whales	4/21/2021 86 FR21082	Specific areas designated as critical habitat for the Mexico DPS of humpback whales contain approximately 116,098 nmi^2 of marine habitat in the North Pacific Ocean, including areas within portions of the eastern Bering Sea, Gulf of Alaska, and California Current Ecosystem. The PBF for this species is The PBF for this species is prey species of sufficient quality, abundance, and accessibility to support feeding and population growth.

We also supplement the information provided in the BA with the following summary of the effects of climate change on the status of ESA listed species considered in this opinion and aquatic habitat at large.

Climate change is likely to play an increasingly important role in determining the abundance and distribution of ESA-listed species, and the conservation value of designated critical habitats, in the Pacific Northwest. These changes will not be spatially homogeneous across the Pacific Northwest. Major ecological realignments are already occurring in response to climate change (IPCC Working Group II, 2022). Long-term trends in warming have continued at global, national and regional scales. Global surface temperatures in the last decade (2010s) were estimated to be 1.09 °C higher than the 1850-1900 baseline period, with larger increases over land ~1.6 °C compared to oceans ~0.88 (IPCC WGI, 2021). The vast majority of this warming has been attributed to anthropogenic releases of greenhouse gases (IPCC WGI, 2021). Globally, 2014-2018 were the 5 warmest years on record both on land and in the ocean (2018 was the 4th warmest) (NOAA NCEI 2022). Events such as the 2013-2016 marine heatwave (Jacox et al. 2018) have been attributed directly to anthropogenic warming in the annual special issue of Bulletin of the American Meteorological Society on extreme events (Herring et al. 2018). Global warming and anthropogenic loss of biodiversity represent profound threats to ecosystem functionality (IPCC WGII 2022). These two factors are often examined in isolation, but likely have interacting effects on ecosystem function.

Updated projections of climate change are similar to or greater than previous projections (IPCC Working Group I, 2021). NMFS is increasingly confident in our projections of changes to freshwater and marine systems because every year brings stronger validation of previous predictions in both physical and biological realms. Retaining and restoring habitat complexity, access to climate refuges (both flow and temperature) and improving growth opportunity in both freshwater and marine environments are strongly advocated in the recent literature (Siegel and Crozier, 2020a).

Climate change is systemic, influencing freshwater, estuarine, and marine conditions. Other systems are also being influenced by changing climatic conditions. Literature reviews on the impacts of climate change on Pacific salmon (Crozier, 2015, 2016, 2017; Crozier and Siegel, 2018; Siegel and Crozier, 2019, 2020b) have collected hundreds of papers documenting the major themes relevant for salmon. Here we describe habitat changes relevant to Pacific salmon and steelhead, prior to describing how these changes result in the varied specific mechanisms impacting these species in subsequent sections.

<u>Forests</u>

Climate change will impact forests of the western U.S., which dominate the landscape of many watersheds in the region. Forests are already showing evidence of increased drought severity, forest fire, and insect outbreak (Halofsky et al., 2020). Additionally, climate change will affect tree reproduction, growth, and phenology, which will lead to spatial shifts in vegetation. Halofsky et al. (2018) projected that the largest changes will occur at low- and high-elevation forests, with expansion of low-elevation dry forests and diminishing high-elevation cold forests and subalpine habitats.

Forest fires affect salmon streams by altering sediment load, channel structure, and stream temperature through the removal of canopy. Holden et al. (2018) examined environmental factors contributing to observed increases in the extent of forest fires throughout the western U.S. They found strong correlations between the number of dry-season rainy days and the annual extent of forest fires, as well as a significant decline in the number of dry-season rainy days over the study period (1984-2015). Consequently, predicted decreases in dry-season precipitation, combined with increases in air temperature, will likely contribute to the existing trend toward more extensive and severe forest fires and the continued expansion of fires into higher elevation and wetter forests (Alizadeh et al., 2021).

Agne et al. (2018) reviewed literature on insect outbreaks and other pathogens affecting coastal Douglas-fir forests in the Pacific Northwest and examined how future climate change may influence disturbance ecology. They suggest that Douglas-fir beetle and black stain root disease could become more prevalent with climate change, while other pathogens will be more affected by management practices. Agne et al. (2018) also suggested that due to complex interacting effects of disturbance and disease, climate impacts will differ by region and forest type.

Freshwater Environments

The following is excerpted from Siegel and Crozier (2019), who present a review of recent scientific literature evaluating effects of climate change, describing the projected impacts of climate change on instream flows:

> Cooper et al. (2018) examined whether the magnitude of low river flows in the western U.S., which generally occur in September or October, are driven more by summer conditions or the prior winter's precipitation. They found that while low flows were more sensitive to summer evaporative demand than to winter precipitation, interannual variability in winter precipitation was greater. Malek et al. (2018), predicted that summer evapotranspiration is likely to increase in conjunction with declines in snowpack and increased variability in winter precipitation. Their results suggest that low summer flows are likely to become lower, more variable, and less predictable.

The effect of climate change on ground water availability is likely to be uneven. Sridhar et al. (2018) coupled a surface-flow model with a ground-flow model to improve predictions of surface water availability with climate change in the Snake River Basin. Projections using RCP 4.5 and 8.5 emission scenarios suggested an increase in water table heights in downstream areas of the basin and a decrease in upstream areas.

As cited in Siegel and Crozier (2019), Isaak et al. (2018), examined recent trends in stream temperature across the Western U.S. using a large regional dataset. Stream warming trends paralleled changes in air temperature and were pervasive during the low-water warm seasons of 1996-2015 (0.18-0.35°C/decade) and 1976-2015 (0.14-0.27°C/decade). Their results show how continued warming will likely affect the cumulative temperature exposure of migrating sockeye salmon O. nerka and the availability of suitable habitat for brown trout Salmo trutta and rainbow trout O. mykiss. Isaak et al. (2018) concluded that most stream habitats will likely remain suitable for salmonids in the near future, with some becoming too warm. However, in cases where habitat access is currently restricted by dams and other barriers salmon and steelhead will be confined to downstream reaches typically most at risk of rising temperatures unless passage is restored (FitzGerald et al., 2021; Myers et al., 2018).

Streams with intact riparian corridors and that lie in mountainous terrain are likely to be more resilient to changes in air temperature. These areas may provide refuge from climate change for a number of species, including Pacific salmon. Krosby et al. (2018), identified potential stream refugia throughout the Pacific Northwest based on a suite of features thought to reflect the ability of streams to serve as such refuges. Analyzed features include large temperature gradients, high canopy cover, large relative stream width, low exposure to solar radiation, and low levels of human modification. They created an index of refuge potential for all streams in the region, with mountain area streams scoring highest. Flat lowland areas, which commonly contain migration corridors, were generally scored lowest, and thus were prioritized for conservation and restoration. However, forest fires can increase stream temperatures dramatically in short time-spans by removing riparian cover (Koontz et al., 2018), and streams that lose their snowpack with climate change may see the largest increases in stream temperature due to the removal of temperature buffering (Yan et al., 2021). These processes may threaten some habitats that are currently considered refugia.

Marine and Estuarine Environments

Along with warming stream temperatures and concerns about sufficient groundwater to recharge streams, a recent study projects nearly complete loss of existing tidal wetlands along the U.S. West Coast, due to sea level rise (Thorne et al., 2018). California and Oregon showed the greatest threat to tidal wetlands (100%), while 68% of Washington tidal wetlands are expected to be submerged. Coastal development and steep topography prevent horizontal migration of most wetlands, causing the net contraction of this crucial habitat.

Rising ocean temperatures, stratification, ocean acidity, hypoxia, algal toxins, and other oceanographic processes will alter the composition and abundance of a vast array of oceanic species. In particular, there will be dramatic changes in both predators and prey of Pacific salmon, salmon life history traits and relative abundance. Siegel and Crozier (2019) observe that changes in marine temperature are likely to have a number of physiological consequences on fishes themselves. For example, in a study of small planktivorous fish, Gliwicz et al. (2018) found that higher ambient temperatures increased the distance at which fish reacted to prey. Numerous fish species (including many tuna and sharks) demonstrate regional endothermy, which in many cases augments eyesight by warming the retinas. However, Gliwicz et al. (2018) suggest that ambient temperatures can have a similar effect on fish that do not demonstrate this trait. Climate change is likely to reduce the availability of biologically essential omega-3 fatty acids produced by phytoplankton in marine ecosystems. Loss of these lipids may induce cascading trophic effects, with distinct impacts on different species depending on compensatory mechanisms (Gourtay et al., 2018). Reproduction rates of many marine fish species are also likely to be altered with temperature (Veilleux et al., 2018). The ecological consequences of these effects and their interactions add complexity to predictions of climate change impacts in marine ecosystems.

Perhaps the most dramatic change in physical ocean conditions will occur through ocean acidification and deoxygenation. It is unclear how sensitive salmon and steelhead might be to the direct effects of ocean acidification because of their tolerance of a wide pH range in freshwater (although see Ou et al. (2015); (Williams et al., 2019)), however, impacts of ocean acidification and hypoxia on sensitive species (e.g., plankton, crabs, rockfish, groundfish) will likely affect salmon indirectly through their interactions as predators and prey. Similarly, increasing frequency and duration of harmful algal blooms may affect salmon directly, depending on the toxin (e.g., saxitoxin vs domoic acid), but will also affect their predators (seabirds and mammals). The full effects of these ecosystem dynamics are not known but will be complex. Within the historical range of climate variability, less suitable conditions for salmonids (e.g., warmer temperatures, lower stream flows) have been associated with detectable declines in many of these listed units, highlighting how sensitive they are to climate drivers (Ford, 2022; Lindley et al., 2009; Ward et al., 2015; Williams et al., 2016). In some cases, the combined and potentially additive effects of poorer climate conditions for fish and intense anthropogenic impacts caused the population declines that led to these population groups being listed under the ESA (Crozier et al., 2019).

Climate change effects on salmon and steelhead

In freshwater, year-round increases in stream temperature and changes in flow will affect physiological, behavioral, and demographic processes in salmon, and change the species with which they interact. For example, as stream temperatures increase, many native salmonids face increased competition with more warm-water tolerant invasive species. Changing freshwater temperatures are likely to affect incubation and emergence timing for eggs, and in locations where the greatest warming occurs may affect egg survival, although several factors impact intergravel temperature and oxygen (e.g., groundwater influence) as well as sensitivity of eggs to thermal stress (Crozier et al., 2021). Changes in temperature and flow regimes may alter the amount of habitat and food available for juvenile rearing, and this in turn could lead to a restriction in the distribution of juveniles, further decreasing productivity through density dependence. For migrating adults, predicted changes in freshwater flows and temperatures will likely increase exposure to stressful temperatures for many salmon and steelhead populations, and alter migration travel times and increase thermal stress accumulation for ESUs or DPSs with early-returning (i.e. spring- and summer-run) phenotypes associated with longer freshwater holding times (Crozier et al., 2020; FitzGerald et al., 2021). Rising river temperatures increase the energetic cost of migration and the risk of en route or pre-spawning mortality of adults with long freshwater migrations, although populations of some ESA-listed salmon and steelhead may be able to make use of cool-water refuges and run-timing plasticity to reduce thermal exposure (Barnett et al., 2020; Keefer et al., 2018).

Marine survival of salmonids is affected by a complex array of factors including prey abundance, predator interactions, the physical condition of salmon within the marine environment, and carryover effects from the freshwater experience (Burke et al., 2013; Holsman et al., 2012). It is generally accepted that salmon marine survival is size-dependent, and thus larger and faster growing fish are more likely to survive (Gosselin et al., 2021). Furthermore, early arrival timing in the marine environment is generally considered advantageous for populations migrating through the Columbia River. However, the optimal day of arrival varies across years, depending on the seasonal development of productivity in the California Current, which affects prey available to salmon and the risk of predation (Chasco et al., 2021). Siegel and Crozier (2019) point out the concern that for some salmon populations, climate change may drive mismatches between juvenile arrival timing and prey availability in the marine environment. However, phenological diversity can contribute to metapopulation-level resilience by reducing the risk of a complete mismatch. Carr-Harris et al. (2018), explored phenological diversity of marine migration timing in relation to zooplankton prey for sockeye salmon *O. nerka* from the Skeena River of Canada. They found that sockeye migrated over a period of more than 50 days, and populations from higher elevation and further inland streams arrived in the estuary later, with different populations encountering distinct prey fields. Carr-Harris et al. (2018) recommended that managers maintain and augment such life-history diversity.

Synchrony between terrestrial and marine environmental conditions (e.g., coastal upwelling, precipitation and river discharge) has increased in spatial scale causing the highest levels of synchrony in the last 250 years (Black et al., 2018). A more synchronized climate combined with simplified habitats and reduced genetic diversity may be leading to more synchrony in the productivity of populations across the range of salmon (Braun et al., 2016). For example, salmon productivity (recruits/spawner) has also become more synchronized across Chinook populations from Oregon to the Yukon (Dorner et al., 2018; Kilduff et al., 2014). In addition, Chinook salmon have become smaller and younger at maturation across their range (Ohlberger et al., 2018). Other Pacific salmon species (Stachura et al., 2014) and Atlantic salmon (Olmos et al., 2020) also have demonstrated synchrony in productivity across a broad latitudinal range.

At the individual scale, climate impacts on salmon in one life stage generally affect body size or timing in the next life stage and negative impacts can accumulate across multiple life stages (Gosselin et al., 2021; Healey, 2011; Wainwright and Weitkamp, 2013). Changes in winter precipitation will likely affect incubation and/or rearing stages of most populations. Changes in the intensity of cool season precipitation, snow accumulation, and runoff could influence migration cues for fall, winter and spring adult migrants, such as coho and steelhead. Egg survival rates may suffer from more intense flooding that scours or buries redds. Changes in hydrological regime, such as a shift from mostly snow to more rain, could drive changes in life history, potentially threatening diversity within an ESU (Beechie et al., 2006). Changes in summer temperature and flow will affect both juvenile and adult stages in some populations, especially those with yearling life histories and summer migration patterns (Crozier and Zabel, 2006; Crozier et al., 2019; Crozier et al., 2010).

At the population level, the ability of organisms to genetically adapt to climate change depends on how much genetic variation currently exists within salmon populations, as well as how selection on multiple traits interact, and whether those traits are linked genetically. While genetic diversity may help populations respond to climate change, the remaining genetic diversity of many populations is highly reduced compared to historic levels. For example, Johnson et al. (2018), compared genetic variation in Chinook salmon from the Columbia River Basin between contemporary and ancient samples. A total of 84 samples determined to be Chinook salmon were collected from vertebrae found in ancient middens and compared to 379 contemporary samples. Results suggest a decline in genetic diversity, as demonstrated by a loss of mitochondrial haplotypes as well as reductions in haplotype and nucleotide diversity. Genetic losses in this comparison appeared larger for Chinook from the mid-Columbia than those from the Snake River Basin. In addition to other stressors, modified habitats and flow regimes may create unnatural selection pressures that reduce the diversity of functional behaviors (Sturrock et al., 2020). Managing to conserve and augment existing genetic diversity may be increasingly important with more extreme environmental change (Anderson et al., 2015), though the low levels of remaining diversity present challenges to this effort (Freshwater et al., 2019). Salmon historically maintained relatively consistent returns across variation in annual weather through the portfolio effect (Schindler et al., 2015), in which different populations are sensitive to different climate drivers. Applying this concept to climate change, Anderson et al. (2015) emphasized the additional need for populations with different physiological tolerances. Loss of the portfolio increases volatility in fisheries, as well as ecological systems, as demonstrated for Fraser River and Sacramento River stock complexes (Freshwater et al., 2019; Munsch et al., 2022).

The BA summarizes the critical habitat physical and biological features (PBFs) in the action area for salmon and steelhead critical habitat in Table 2.2 on page 13 and stresses the poor water quality and predation threats in the estuary and action area. The BA summarizes the critical habitat PBFs in the action area for Southern DPS green sturgeon in Table 2-4 on page 18 and stresses the poor water quality and degraded sediment quality in the estuary and action area. The BA summarizes the critical habitat PBFs in the action area for eulachon critical habitat in Table 2-5 on page 19 and stresses the poor water quality in the estuary and action area.

"Action area" means all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action (50 CFR 402.02). The BA describes the action area on pages 5 through 8. The BA determined that the maximum extent of effects from the proposed action is the radial distance from the project site to a point where sound from vibratory pile driving of 36 inch diameter piles decreases below the level that affects the behavior of Stellar sea lions[1], 120 decibels (root mean square re: 1 microPascal, dB_{RMS}), or intercepts the shoreline or a solid barrier that blocks sound transmission. This distance is up to 7,943 meters. Since Stellar sea lions in the Columbia River are no longer ESA listed the action area boundary should be the radial distance from the project to a point where sound from impact pile driving of 36 inch diameter steel pipe piles attenuated with a bubble curtain decreases below the level that affects salmonid behavior, 150 dB_{RMS} or intercepts a shoreline or solid barrier that blocks sound transmission. This distance is up to 736 meters (Optional Multi-Species Pile Driving Calculator Version 1.0-Multi-Species: 2021). Since 736 meters is smaller than the radial distance calculated in the BA for Stellar sea lions, all of the baseline and effects analysis in the BA are relevant to this smaller action area.

The "environmental baseline" includes the past and present impacts of all Federal, state, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section

[1] The Steller sea lion was listed Threatened on November 26, 1990 (50 CFR Part 227) and listing revised to reclassify two DPS, western DPS and eastern DPS on June 4, 1997. The eastern DPS was delisted on December 4, 2013. The western DPS is listed Endangered and occurs west of 144°W longitude (near Suckling, AK). For this BA, the eastern DPS will be addressed due to protections under the Marine Mammal Protection Act.

7 consultation, and the impact of state or private actions which are contemporaneous with the consultation in process (50 CFR 402.02)

The BA describes the Environmental Baseline of the action area in section 3 starting on page 20. The BA includes discussions of the effects of the Federal Columbia River Power System (FCRPS) on water temperature and seasonal flow in the estuary and references NMFS biological opinion on the operation and maintenance of the FCRPS dams (WCRO-2020-00113). The BA discusses the baseline effects of dredging and pile dikes for the Columbia and Lower Willamette Federal Navigation Channel Project on fish passage, water quality and nearshore habitat. The BA discusses the development of the Astoria riverfront and references NMFS' biological opinion on the reconstruction of the City of Astoria 17th Street Dock (WCR-2011-02731). The BA also discusses chemicals that degrade water quality in the action area. Finally, the BA states that the action area is important juvenile rearing and adult and juvenile migration habitat for all salmon and steelhead species, a migration corridor for adult and larval eulachon and foraging habitat for adult and subadult green sturgeon.

Under the ESA, "effects of the action" means the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action, that will be added to the environmental baseline (50 CFR 402.02). Indirect effects are those that are caused by the proposed action and are later in time, but still are reasonably certain to occur.

The BA provides a detailed discussion and comprehensive assessment of the effects of the proposed action in section 4 of the BA, and is adopted here. NMFS has evaluated this section and after our independent, science-based evaluation determined it meets our regulatory and scientific standards with the following supplements.

We supplement the BA analysis (page 22) of the effects of suspended sediment from pile driving with the following. The BA describes a zone of turbidity between 0.5 and 1 NTU extending 150 feet from the pile driver and lists behavioral and physical effects of exposure to turbidity. Physical effects are a function of the exposure duration and concentration of the suspended sediment causing the turbidity (Newcombe and Jensen, 1996; Wilber and Clarke, 2001). Weston Solutions (2004) measured suspended sediment concentrations associated with vibratory pile driving at the mouth of Jimmycomelately Creek in Sequim Bay. They reported suspended sediment concentrations of 100s of milligrams per liter from the prop of the tug pulling the pile driver barge but only reported suspended sediment concentrations of 5-10 milligrams per liter above background in a 5 to 10 meter long plume from the vibratory pile removal itself that rapidly dispersed when the pile was pulled. Wilber and Clarks (2001) literature review found that exposure of juvenile salmon to suspended sediment concentrations of 10-100 milligrams per liter for minutes to hours resulted in behavioral effects only. This supports the analysis and conclusions in the BA.

We supplement the BA analysis of the effects of impact pile driving sound pressure waves on BA page 25 and Table 4-2 on page 26 with the following. Table 3, below, provides the distance to the onset of physical injury or behavioral response to Pacific salmon, green sturgeon and eulachon reported in the BA and by the NMFS calculator (Optional Multi-Species Pile Driving

Calculator Version 1.0-Multi-Species: 2021) for 2000 strikes to a 36 inch diameter steel pipe pile with 5 decibels of sound attenuation from a bubble curtain, The NMFS calculated distances to the onset of injury or altered behavior are an order of magnitude less than the distances calculated for the BA leading us to believe that the values in the BA should be divided by 10. The values shown in row "NMFS calculator" are consistent with the exposure-response analysis in the BA. This means that any fish within 4 meters of a pile during a single impact strike or a small fish within 86 meters of 2000 impact strikes would will likely be injured or killed.

Table 3. Calculated distance from source to effect threshold impact pile driving

Effect	**Injury or death from exposure to the peak amplitude of a single strike**	**Injury or death from exposure to cumulative sound exposure level (SEL) from 2000 strikes for fish > 2 grams EL**	**Injury or death from cumulative SEL from 2000 strikes for fish less than 2 grams**	**Altered behavior from exposure to root mean square of sound pressure**
Threshold	$206\ dB$ $re\colon 1\ \mu Pa$	$187\ dB$ $re\colon 1 \mu Pa^2 sec$	$183\ dB$ $re\colon 1\ \mu Pa^2 sec$	$150\ dB_{RMS}$ $re\colon 1\ uPa$
Distance to threshold in BA	18 meters	859 meters	1585 meters	7356 meter
Distance to threshold with NMFS calculator	4 meters	86 meters	158 meters	858 meters

We supplement the BA analysis of delayed consequences in section 4.2 as follows. The BA on page 28 addresses the effects of continuing to moor American Cruise Line vessels in the action area into the future. On April 24, 2022, we had a phone conversation with William Sharpe of the Confederated Tribes of the Yakama Nation (Tribe). He reported that the Tribe was in consultation with American Cruise Lines on the effects of their new, expanded or reconstructed overwater structure at Cascade Locks on nearby Tribal fisheries. This project will likely require a USACE permit and an ESA Section 7 consultation with NMFS, although we have not received a consultation request from the USACE or participated in any pre-consultation meetings or activities. All American Cruise Lines infrastructure projects on the Columbia River that affect ESA-listed anadromous species are consequences of each other so we add here that a consequence of the proposed action is another American Cruise Lines overwater structure construction project that will likely affect ESA listed salmon and steelhead near Cascade Locks, Oregon.

"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). 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. Section 5 of the BA on page 28 explains why there are no cumulative effects for this proposed action. We supplement this information by adding that non-federal actions outside of the action area are likely to increase over the life of the structures, and to influence the action area. These include water quality impairments from upland conversion of land from natural or rural conditions to agriculture, suburban development, and commercial uses, which can introduce stormwater, municipal, or industrial discharges. Climate effects, described above, are also likely to intensify within the action area as well, over the life of the structures.

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 to the environmental baseline and the cumulative effects, taking into account the status of the species and critical habitat, 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.

As indicated in Table 1, ESA-listed salmon, steelhead, eulachon and green sturgeon species are at a low level of persistence and risk of extinction. The BA section 2 makes it clear that individuals from all of the Table 1 species populations are likely to migrate into or near the action area at some point in their life history and that only sockeye salmon and green sturgeon are not likely to be in the action area at any time in the water-work window nor to be exposed to direct effects of the proposed action. BA section 3 makes it clear that all fish in the action area encounter habitat conditions that have been degraded by the presence of overwater structures, maintenance dredging, altered flow, reduced water quality and the loss of vegetated riparian areas. The BA section 4 describes that the proposed action will create up to 20 days of disturbance in the action area where fish that enter the action area will be exposed to behavior modifying effects, and the response of some individual could even include injurious or lethal effects. Individual fish that enter the action area after construction is complete, and for the life of the mooring dolphins, will encounter reduced rearing conditions because piles displace shallow water areas and permanently remove benthic prey in that location, while the vessels that use the mooring dolphins can impair water quality, aquatic vegetation, and prey recruitment.

The last element in the integration of effects includes a consideration of the cumulative effects anticipated in the action area. Recovery of the action area from the baseline condition to properly functioning conditions is likely to be extremely slow because of continuing anthropogenic uses that are expected to delay, or further degrade the action area; these future actions are likely to continue to cause slight negative pressure on population abundance trends into the future. The project's effects temporary and permanent effects are both negative. However, even when we consider the current status of the threatened and endangered fish populations and degraded environmental baseline within the action area, and the cumulative effects, the proposed action's effect on abundance of any particular species is expected to be very low, and dispersed across various populations, such that distribution, diversity, or productivity of any of the component populations of the ESA-listed species are not discernibly altered. Because the proposed action's reduction in abundance will not appreciably reduce the productivity, spatial structure, or diversity the affected populations, the action, even when combined with a degraded environmental baseline and continual pressure from cumulative effects, we determine that the action will not appreciably reduce the likelihood of survival or recovery any of the listed species considered in this opinion.

With regards to critical habitat, because the proposed action is a replacement of existing structures, the reductions on PBFs are primarily temporary, associated with construction, and is not expected to expand the amount of use. The long term presence of the structures does not increase the amount of habitat diminishment, but does retain the diminishment for several decades. The project will not likely to aggravate limiting factors in the action area, but does constrain the conservation role to its current degraded level.

In summary, ESA-listed salmon, steelhead, green sturgeon and eulachon, occupying the action area will be exposed to effects from the proposed action but NMFS analysis did not identify effects with intensities or durations that would result in a reduction of the value of the designated critical habitat for migration or rearing, or reductions in productivity, diversity, or spatial structure of exposed populations, thus the survival and recovery of ESA-listed species are also not reduced.

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, UCR spring-run Chinook salmon, SR spring-summer run Chinook salmon, SR fall run Chinook salmon, CR chum salmon, LCR coho salmon, SR sockeye salmon, LCR steelhead, UWR steelhead, MCR steelhead, UCR steelhead, SR basin steelhead, Southern DPS of green sturgeon, or Southern DPS of eulachon or destroy or adversely modify their designated critical habitat.

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.

Amount or Extent of Take

In the biological opinion, NMFS determined that incidental take is reasonably certain to occur as follows: The proposed pile driving will take place when juvenile and/or adult individuals of LCR Chinook salmon, UWR Chinook salmon, UCR spring-run Chinook salmon, SR spring-summer run Chinook salmon, SR fall run Chinook salmon, CR chum salmon, LCR coho salmon, SR sockeye salmon, LCR steelhead, UWR steelhead, MCR steelhead, UCR steelhead, SR basin steelhead, Southern DPS of green sturgeon, or Southern DPS of eulachon may enter the action area.

Incidental take caused by the adverse effects of the proposed action will occur among individuals of the species identified above in the form of harm (altered habitat that results in injury or death) and from exposure to impact pile driver noise and sound pressure waves and suspended sediment. A definitive number of ESA-listed fish that will be harmed cannot be estimated or measured because of the highly variable presence of species over time, and the inability to observe injured or dead specimens. Instead, NMFS will use habitat–based surrogates that are causally related to harm to account for the take, which is called an "extent" of take.

For this proposed action, the extent of take from impact pile driving is related to the up to 10,000 impact blows needed to install the 5 piles. The extent of take from suspended sediment from pile removal and excavation is related to the up to 150 foot radius from the suspended sediment source to the point where the suspended sediment concentration returns to background. These are measurable and verifiable metrics by which the action agency or other observers can determine if the extent of take has been exceeded. The marina and the action agency have included multiple best practices to minimize environmental perturbations that could cause harm. Therefore we have no measures to further reduce take, other than monitoring.

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.

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).

For this proposed action, the reasonable and prudent measure is to monitor incidental take from pile driving and suspended sediment.

Terms and Conditions

In order to be exempt from the prohibitions of section 9 of the ESA, the Federal action agency must comply (or must ensure that any applicant complies) with the following terms and conditions. The USACE or any applicant has a continuing duty to monitor the impacts of incidental take and must 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.

The terms and conditions described below are non-discretionary, and the USACE or any applicant must comply with them in order to implement the RPMs (50 CFR 402.14). The

USACE or any applicant has a continuing duty to monitor the impacts of incidental take and must 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.

To accomplish the reasonable and prudent measure, above, the terms and conditions for this proposed action are to prepare and provide NMFS with a plan before construction begins describing how impacts of the incidental take on listed species in the action area would be monitored and documented, and a report within 90 days of the completion of construction that documents incidental take monitoring results.

Species and Critical Habitats Not Likely to be Adversely Affected

The USCG will engage in pile removal and pile installation, which will rely on a vibratory driver, and impact driving. A bubble curtain will be utilized to reduce the transmission of sound in the aquatic environment. The proponent included in their proposed action a monitoring plan during pile driving to ensure that Steller sea lions would not be adversely affected, as monitoring would cease work until these marine mammals were no longer within the zone that injury would occur. On August 17.2022, the USACE provided an electronic email confirming that soft start, monitoring, and stop work protocols would be extended to both humpback whales and SRKW.

Because the protocols allow marine mammals to detect noise and provides a window of time to avoid the area of increased sound before the remainder of pile work begins, and because monitoring which detects either marine mammal requires that work cease until the animals are no longer present in the area affected by increased sound, NMFS considers exposure to be very brief, with avoidance behavior to be the likely response. NMFS does not expect harm or injury as a consequence of either sound or avoidance. For this reason, we believe exposure and response of these two species (inclusive of both the Central America and Mexico DPSs of humpback whales) is insignificant.

The designated critical habitat for these species is also insignificantly affected because prey and water quality, PBFs of the critical habitat, are not appreciably altered by the temporary or long-lasting effects of the proposed action.

Reinitiation of Consultation

As 50 CFR 402.16 states, reinitiation of formal consultation is required 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 agency action is subsequently modified in a manner that causes an effect on the listed species or critical habitat that was not considered in this opinion, or (4) a new species is listed or critical habitat designated that may be affected by the action

NMFS also reviewed the proposed action for potential effects on essential fish habitat (EFH) designated under the Magnuson-Stevens Fishery Conservation and Management Act (MSA), including conservation measures and any determination you made regarding the potential effects of the action. This review was conducted pursuant to section 305(b) of the MSA, implementing regulations at 50 CFR 600.920, and agency guidance for use of the ESA consultation process to complete EFH consultation.

The project elements that could potentially impact groundfish, pelagic, and salmon species' EFH are pile removal and installation general construction activities.

1. Pile removal and pile driving could result in temporary increases in turbidity.
2. Vibratory pile removal and installation and impact driving/proofing may result in elevated sound levels for not more than 100 total minutes per pile (45 minutes for vibratory and up to 55 minutes for impact) or 500 total minutes over up to 20 days for the Project. Potentially injurious sound pressure levels in water would be limited to areas within 158 meters.
3. There is potential for an unintentional release of fuel, lubricants, or hydraulic fluid from equipment that could lead to adverse impacts to the water column EFH if allowed to enter waters of the US.

Conservation Recommendations

1. All work in aquatic areas will be completed during the November 1 to February 28 in-water work period per the USACE guidance.
2. Short-term impacts to water quality during construction will be minimized through adherence to BMPs.
3. The contractor will comply with applicable State water quality standards (WAC 173-201A) and implement corrective measures if temporary water quality standards are exceeded.
4. The contractor will comply with the substantive requirements of the Hydraulic Code.
5. Excess or waste materials and debris will be disposed of at an appropriate upland facility and will not be allowed to enter the Columbia River.
6. Fuel hoses, oil drums, oil or fuel transfer valves and fittings, etc., shall be checked regularly for drips or leaks, and shall be maintained and stored properly to prevent spills into the Columbia River. Proper security shall also be maintained to prevent vandalism.
7. Corrective actions will be taken in the event of any discharge of oil, fuel, or chemicals into the Columbia River. Corrective actions will include: In the event of a spill, containment and cleanup efforts will begin immediately and be completed as soon as possible, taking precedence over normal work. Cleanup will include proper disposal of any spilled material and used cleanup material. The cause of the spill shall be assessed and appropriate action will be taken to prevent further incidents or environmental damage.
8. The contractor will have a spill containment kit, including oil-absorbent materials, on site to be used in the event of a spill or if any oil product is observed in the water.

This letter underwent pre-dissemination review using standards for utility, integrity, and objectivity in compliance with applicable guidelines issued under the Data Quality Act (section 515 of the Treasury and General Government Appropriations Act for Fiscal Year 2001, Public Law 106-554). The biological opinion will be available through NOAA Institutional Repository [https://repository.library.noaa.gov/welcome]. A complete record of this consultation is on file at Lacey, Washington.

Please direct questions regarding this letter to Tom Hausmann in Portland, Oregon, at Tom.Hausmann@noaa.gov, or 503-231-2315.

This letter underwent pre-dissemination review using standards for utility, integrity, and objectivity in compliance with applicable guidelines issued under the Data Quality Act (section 515 of the Treasury and General Government Appropriations Act for Fiscal Year 2001, Public

Sincerely,

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

cc: Brad Johnson, USACE

List of References:

Agne, M.C., Beedlow, P.A., Shaw, D.C., Woodruff, D.R., Lee, E.H., Cline, S.P., and Comeleo, R.L. (2018). Interactions of predominant insects and diseases with climate change in Douglas-fir forests of western Oregon and Washington, USA. Forest Ecol Manag *409*, 317-332.

Alizadeh, M.R., Abatzoglou, J.T., Luce, C.H., Adamowski, J.F., Farid, A., and Sadegh, M. (2021). Warming enabled upslope advance in western US forest fires. P Natl Acad Sci USA *118*.

Anderson, S.C., Moore, J.W., McClure, M.M., Dulvy, N.K., and Cooper, A.B. (2015). Portfolio conservation of metapopulations under climate change. Ecol Appl *25*, 559-572.

Barnett, H.K., Quinn, T.P., Bhuthimethee, M., and Winton, J.R. (2020). Increased prespawning mortality threatens an integrated natural- and hatchery-origin sockeye salmon population in the Lake Washington Basin. Fish Res *227*.

Beechie, T., Buhle, E., Ruckelshaus, M., Fullerton, A., and Holsinger, L. (2006). Hydrologic regime and the conservation of salmon life history diversity. Biol Conserv *130*, 560-572.

Black, B.A., van der Sleen, P., Di Lorenzo, E., Griffin, D., Sydeman, W.J., Dunham, J.B., Rykaczewski, R.R., Garcia-Reyes, M., Safeeq, M., Arismendi, I*., et al.* (2018). Rising synchrony controls western North American ecosystems. Global Change Biol *24*, 2305-2314.

Braun, D.C., Moore, J.W., Candy, J., and Bailey, R.E. (2016). Population diversity in salmon: linkages among response, genetic and life history diversity. Ecography *39*, 317-328.

Burke, B.J., Peterson, W.T., Beckman, B.R., Morgan, C., Daly, E.A., and Litz, M. (2013). Multivariate Models of Adult Pacific Salmon Returns. Plos One *8*.

Carr-Harris, C.N., Moore, J.W., Gottesfeld, A.S., Gordon, J.A., Shepert, W.M., Henry, J.D.J., Russell, H.J., Helin, W.N.B., Doolan, D.J., and Beacham, T.D. (2018). Phenological Diversity of Salmon Smolt Migration Timing within a Large Watershed. T Am Fish Soc *147*, 775-790.

Chasco, B., Burke, B., Crozier, L., and Zabel, R. (2021). Differential impacts of freshwater and marine covariates on wild and hatchery Chinook salmon marine survival. Plos One *16*.

Cooper, M.G., Schaperow, J.R., Cooley, S.W., Alam, S., Smith, L.C., and Lettenmaier, D.P. (2018). Climate Elasticity of Low Flows in the Maritime Western US Mountains. Water Resour Res *54*, 5602-5619.

Crozier, L. (2015). Impacts of Climate Change on Columbia River Salmon: A review of the scientific literature published in 2014. Pages D1-D50 in Endangered Species Act Section 7(a)(2) supplemental biological opinion: consultation on remand for operation of the Federal Columbia River Power System. (U.S. National Marine Fisheries Service, Northwest Region.).

Crozier, L. (2016). Impacts of Climate Change on Columbia River Salmon: A review of the scientific literature published in 2015. Pages D1-D50 in Endangered Species Act Section 7(a)(2) supplemental biological opinion: consultation on remand for operation of the Federal Columbia River Power System. (U.S. National Marine Fisheries Service, Northwest Region.).

Crozier, L. (2017). Impacts of Climate Change on Columbia River Salmon: A review of the scientific literature published in 2016. Pages D1-D50 in Endangered Species Act Section 7(a)(2) supplemental biological opinion: consultation on remand for operation of the Federal Columbia River Power System. (U.S. National Marine Fisheries Service, Northwest Region.).

Crozier, L., and Zabel, R.W. (2006). Climate impacts at multiple scales: evidence for differential population responses in juvenile Chinook salmon. J Anim Ecol *75*, 1100-1109.

Crozier, L.G., Burke, B.J., Chasco, B.E., Widener, D.L., and Zabel, R.W. (2021). Climate change threatens Chinook salmon throughout their life cycle. Commun Biol *4*.

Crozier, L.G., McClure, M.M., Beechie, T., Bograd, S.J., Boughton, D.A., Carr, M., Cooney, T.D., Dunham, J.B., Greene, C.M., Haltuch, M.A*., et al.* (2019). Climate vulnerability assessment for Pacific salmon and steelhead in the California Current Large Marine Ecosystem. Plos One *14*.

Crozier, L.G., and Siegel, J. (2018). Impacts of Climate Change on Columbia River Salmon: A review of the scientific literature published in 2017. Pages D1-D50 in Endangered Species Act Section 7(a)(2) supplemental biological opinion: consultation on remand for operation of the Federal Columbia River Power System. (U.S. National Marine Fisheries Service, Northwest Region.).

Crozier, L.G., Siegel, J.E., Wiesebron, L.E., Trujillo, E.M., Burke, B.J., Sandford, B.P., and Widener, D.L. (2020). Snake River sockeye and Chinook salmon in a changing climate: Implications for upstream migration survival during recent extreme and future climates. Plos One *15*.

Crozier, L.G., Zabel, R.W., Hockersmith, E.E., and Achord, S. (2010). Interacting effects of density and temperature on body size in multiple populations of Chinook salmon. J Anim Ecol *79*, 342-349.

Dorner, B., Catalano, M.J., and Peterman, R.M. (2018). Spatial and temporal patterns of covariation in productivity of Chinook salmon populations of the northeastern Pacific Ocean. Canadian Journal of Fisheries and Aquatic Sciences *75*, 1082-1095.

FitzGerald, A.M., John, S.N., Apgar, T.M., Mantua, N.J., and Martin, B.T. (2021). Quantifying thermal exposure for migratory riverine species: Phenology of Chinook salmon populations predicts thermal stress. Global Change Biol *27*, 536-549.

Ford, M.J. (2022). Biological Viability Assessment Update for Pacific Salmon and Steelhead Listed Under the Endangered Species Act: Pacific Northwest. (U.S. Department of Commerce).

Freshwater, C., Anderson, S.C., Holt, K.R., Huang, A.M., and Holt, C.A. (2019). Weakened portfolio effects constrain management effectiveness for population aggregates. Ecol Appl *29*.

Gliwicz, Z.M., Babkiewicz, E., Kumar, R., Kunjiappan, S., and Leniowski, K. (2018). Warming increases the number of apparent prey in reaction field volume of zooplanktivorous fish. Limnol Oceanogr *63*, S30-S43.

Gosselin, J.L., Buhle, E.R., Van Holmes, C., Beer, W.N., Iltis, S., and Anderson, J.J. (2021). Role of carryover effects in conservation of wild Pacific salmon migrating regulated rivers. Ecosphere *12*.

Gourtay, C., Chabot, D., Audet, C., Le Delliou, H., Quazuguel, P., Claireaux, G., and Zambonino-Infante, J.L. (2018). Will global warming affect the functional need for essential fatty acids in juvenile sea bass (Dicentrarchus labrax)? A first overview of the consequences of lower availability of nutritional fatty acids on growth performance. Mar Biol *165*.

Halofsky, J.E., Peterson, D.L., and Harvey, B.J. (2020). Changing wildfire, changing forests: the effects of climate change on fire regimes and vegetation in the Pacific Northwest, USA. Fire Ecology *16*.

Halofsky, J.S., Conklin, D.R., Donato, D.C., Halofsky, J.E., and Kim, J.B. (2018). Climate change, wildfire, and vegetation shifts in a high-inertia forest landscape: Western Washington, USA. Plos One *13*.

Healey, M. (2011). The cumulative impacts of climate change on Fraser River sockeye salmon (Oncorhynchus nerka) and implications for management (vol 68, pg 718, 2011). Canadian Journal of Fisheries and Aquatic Sciences *68*, 953-953.

Holden, Z.A., Swanson, A., Luce, C.H., Jolly, W.M., Maneta, M., Oyler, J.W., Warren, D.A., Parsons, R., and Affleck, D. (2018). Decreasing fire season precipitation increased recent western US forest wildfire activity. P Natl Acad Sci USA *115*, E8349-E8357.

Holsman, K.K., Scheuerell, M.D., Buhle, E., and Emmett, R. (2012). Interacting Effects of Translocation, Artificial Propagation, and Environmental Conditions on the Marine Survival of Chinook Salmon from the Columbia River, Washington, USA. Conserv Biol *26*, 912-922.

IPCC Working Group I (2021). Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of teh Intergovernmental Panel on Climate Change, P.Z. V. Masson-Delmotte, A. Pirani, S. L. Connors, C. Pean, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M. I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B. R. Matthews, T. K. Maycock, T. Waterfield, O. Yelekci, R. Yu and B. Zhou, ed. (Cambridge University Press).

IPCC Working Group II (2022). Climate Change 2022: Impacts, Adaptation and Vulnerability: Contribution of Working Group II to teh Sixthe Assessment Report of the Intergovernmental Panel of Climate Change., D.C.R. H.O. Portner, M. Tignor, E. Poloczanska, K. Mintenbeck, A. Algria, M. Craig, S. Langsdorf, S. Loschke, V. Moller, A. Okem, and B. Rama, ed. (Cambridge University Press).

Isaak, D.J., Luce, C.H., Horan, D.L., Chandler, G., Wollrab, S., and Nagel, D.E. (2018). Global warming of salmon and trout rivers in the northwestern U.S.: Road to ruin or path through purgatory? T Am Fish Soc *147*, 21.

Johnson, B.M., Kemp, B.M., and Thorgaard, G.H. (2018). Increased mitochondrial DNA diversity in ancient Columbia River basin Chinook salmon Oncorhynchus tshawytscha. Plos One *13*.

Keefer, M.L., Clabough, T.S., Jepson, M.A., Johnson, E.L., Peery, C.A., and Caudill, C.C. (2018). Thermal exposure of adult Chinook salmon and steelhead: Diverse behavioral strategies in a large and warming river system. Plos One *13*.

Kilduff, D.P., Botsford, L.W., and Teo, S.L.H. (2014). Spatial and temporal covariability in early ocean survival of Chinook salmon (Oncorhynchus tshawytscha) along the west coast of North America. Ices J Mar Sci *71*, 1671-1682.

Koontz, E.D., Steel, E.A., and Olden, J.D. (2018). Stream thermal responses to wildfire in the Pacific Northwest. Freshw Sci *37*, 731-746.

Krosby, M., Theobald, D.M., Norheim, R., and Mcrae, B.H. (2018). Identifying riparian climate corridors to inform climate adaptation planning. Plos One *13*.

Lindley, S.T., Grimes, C.B., Mohr, M.S., Peterson, W., Stein, J., and Anderson, J.T. (2009). What caused the Sacramento River fall Chinook stock collapse? (Santa Cruz, CA: NOAA Fisheries West Coast Region).

Malek, K., Adam, J.C., Stockle, C.O., and Peters, R.T. (2018). Climate change reduces water availability for agriculture by decreasing non-evaporative irrigation losses. J Hydrol *561*, 444-460.

Munsch, S.H., Greene, C.M., Mantua, N.J., and Satterthwaite, W.H. (2022). One hundred-seventy years of stressors erode salmon fishery climate resilience in California's warming landscape. Global Change Biol *28*, 2183-2201.

Myers, J.M., Jorgensen, J., Sorel, M., Bond, M., Nodine, T., and Zabel, R. (2018). Upper Willamette River Life Cycle Modeling and the Potential Effects of Climate Change. Draft Report to the U.S. Army Corps of Engineers. (Northwest Fisheries Science Center).

Newcombe, C.P., and Jensen, O.T. (1996). Channel suspended sediment and fisheries: A synthesis for quantitative assessment of risk and impact. N Am J Fish Manage *16*, 30.

Ohlberger, J., Ward, E.J., Schindler, D.E., and Lewis, B. (2018). Demographic changes in Chinook salmon across the Northeast Pacific Ocean. Fish and Fisheries *19*, 13.

Olmos, M., Payne, M.R., Nevoux, M., Prevost, E., Chaput, G., Du Pontavice, H., Guitton, J., Sheehan, T., Mills, K., and Rivot, E. (2020). Spatial synchrony in the response of a long range migratory species (Salmo salar) to climate change in the North Atlantic Ocean. Global Change Biol *26*, 1319-1337.

Ou, M., Hamilton, T.J., Eom, J., Lyall, E.M., Gallup, J., Jiang, A., Lee, J., Close, D.A., Yun, S.S., and Brauner, C.J. (2015). Responses of pink salmon to CO2-induced aquatic acidification. Nat Clim Change *5*, 950-+.

Schindler, D.E., Armstrong, J.B., and Reed, T.E. (2015). The portfolio concept in ecology and evolution. Front Ecol Environ *13*, 257-263.

Siegel, J., and Crozier, L. (2019). Impacts of Climate Change on Salmon of the Pacific Northwest. A review of the scientific literature published in 2018. (Fish Ecology Division, NWFSC).

Siegel, J., and Crozier, L. (2020a). Impacts of Climate Change on Salmon of teh Pacific Northwest. A review of teh scientific literature published in 2018 (National Marine Fisheries Service, Northwest Fisheries Science Center, Fish Ecology Division).

Siegel, J., and Crozier, L. (2020b). Impacts of Climate Change on Salmon of the Pacific Northwest: A review of the scientific literature published in 2019. (National Marine Fisheries Service, Northwest Fisheries Science Center, Fish Ecology Division.).

Sridhar, V., Billah, M.M., and Hildreth, J.W. (2018). Coupled Surface and Groundwater Hydrological Modeling in a Changing Climate. Groundwater *56*, 618-635.

Stachura, M.M., Mantua, N.J., and Scheuerell, M.D. (2014). Oceanographic influences on patterns in North Pacific salmon abundance. Canadian Journal of Fisheries and Aquatic Sciences *71*, 226-235.

Sturrock, A.M., Carlson, S.M., Wikert, J.D., Heyne, T., Nusslé, S., Merz, J.E., Sturrock, H.J., and Johnson, R.C. (2020). Unnatural selection of salmon life histories in a modified riverscape. . Global Change Biol *26*, 12.

Thorne, K., MacDonald, G., Guntenspergen, G., Ambrose, R., Buffington, K., Dugger, B., Freeman, C., Janousek, C., Brown, L., Rosencranz, J., *et al.* (2018). U.S. Pacific coastal wetland resilience and vulnerability to sea-level rise. Sci Adv *4*.

Veilleux, H.D., Donelson, J.M., and Munday, P.L. (2018). Reproductive gene expression in a coral reef fish exposed to increasing temperature across generations. Conserv Physiol *6*.

Wainwright, T.C., and Weitkamp, L.A. (2013). Effects of Climate Change on Oregon Coast Coho Salmon: Habitat and Life-Cycle Interactions. Northwest Sci *87*, 219-242.

Ward, E.J., Anderson, J.H., Beechie, T.J., Pess, G.R., and Ford, M.J. (2015). Increasing hydrologic variability threatens depleted anadromous fish populations. Global Change Biol *21*, 2500-2509.

Wilber, D.H., and Clarke, D.G. (2001). Biological effects of suspended sediments: A review of suspended sediment impacts on fish and shellfish with relation to dredging activities in estuaries. N Am J Fish Manage *21*, 855-875.

Williams, C.R., Dittman, A.H., McElhany, P., Busch, D.S., Maher, M.T., Bammler, T.K., MacDonald, J.W., and Gallagher, E.P. (2019). Elevated CO2 impairs olfactory-mediated neural and behavioral responses and gene expression in ocean-phase coho salmon (Oncorhynchus kisutch). Global Change Biol *25*, 963-977.

Williams, T.H., Spence, B.C., Boughton, D.A., Johnson, R.C., Crozier, L.G., Mantua, N.J., O'Farrell, M.R., and Lindley, S.T. (2016). Viability assessment for Pacific salmon and steelhead listed under the Endangered Species Act: Southwest. (Santa Cruz, CA: NOAA Fisheries Southwest Fisheries Science Center).

Yan, H.X., Sun, N., Fullerton, A., and Baerwalde, M. (2021). Greater vulnerability of snowmelt-fed river thermal regimes to a warming climate. Environ Res Lett *16*.