long-term Project action would potentially reduce the Columbian white-tailed deer carrying capacity on Tenasillahe Island. Proposed Project purchase of Cottonwood/Howard Island, and subsequent introduction of Columbian white-tailed deer to this island complex, may allow for a new, secure sub-population of Columbian white-tailed deer to be established. The Columbian white-tailed deer recovery plan requires, for delisting of the Columbia population, a minimum of 400 Columbian white-tailed deer to be maintained within at least three viable sub-populations in suitable, secure habitat.

4.4.2 Bald Eagle

Bald eagle nests occur at or near several of the ecosystem restoration activity locations. In addition, bald eagles perch on pilings, trees, stumps, mud flats, and other locations throughout the Columbia River and estuary (A. Clark, pers. comm.); these perch locations may be adjacent to the ecosystem restoration projects. Three bald eagle pairs nest either on or in close proximity to Lois Island embayment restoration project (Tongue Point/Mill Creek; Lois Island/John Day Point; Cathlamet Bay), one pair nests on Miller Sands Island near the Miller/Pillar habitat restoration project; two pairs nest on Tenasillahe Island (Tenasillahe/North Hunting Island; Clifton Channel/Tenasillahe West) near the Tenasillahe Island interim and long-term restoration actions; and approximately 30 bald eagle pairs nest within or adjacent to the Columbia River estuary, where the purple loosestrife control activities will occur. Bald eagles do not currently nest on Cottonwood/Howard Islands. Two bald eagle nesting territories occur near the Bachelor Slough restoration project (Bachelor Island; Mallard Slough).

5.0 EFFECTS OF ACTION

5.1 Introduction

The proposed Project has several distinct components, including Project construction and maintenance activities, monitoring and adaptive management, and ecosystem restoration and research actions. The Effects of Action section includes sub-sections that address each Project component separately. Section 7.0 (Conclusion) will aggregate effects from each Project component, and, combined with effects from interrelated and interdependent actions, cumulative effects, environmental baseline, and the proposed action, will determine whether the Project, as a whole, jeopardizes the continued existence of proposed coastal cutthroat trout or threatened bull trout.

Additional analysis of effects to bald eagle and Columbian white-tailed deer from ecosystem restoration actions is provided (5.7 Updated Analysis of Effects for Columbian White-tailed Deer and Bald Eagle). The terrestrial species opinion previously analyzed the effects of Project navigation features on bald eagle and Columbian white-tailed deer and those analyses are incorporated herein by reference (terrestrial species opinion pages 11-18). Since 1999, the navigation features' construction and maintenance actions have not changed in a way that creates different effects, and no additional information on navigation feature construction and maintenance effects is available. Therefore, construction of ecosystem restoration features is the only new Project action and effect that will be analyzed in this opinion for these two species.

As noted in Section 2.0 of these Service opinions (Description of the Proposed Action), several steps were involved in development of the current Proposed action. Those steps included a re-evaluation of potential project effects; an analysis of these potential effects within the framework of an ecosystem-based conceptual model; the development of compliance measures and monitoring conditions to minimize and/or avoid Project impacts; and the development of an adaptive management process to review information from the compliance and monitoring activities and make necessary Project modifications to minimize and/or avoid impacts. The Corps will be responsible to determine how to address the adaptive management team's decisions. By using this "frontloading" approach, the Service and the Corps defined a proposed action that minimized or avoided Project-related effects. Therefore, some potential Project effects will not be discussed herein, as the Corps' proposed action successfully avoids these potential effects.

Several tools were used for the Service's analysis of potential Project effects. To interpret potential Project effects to Lower Columbia River, estuary, and river mouth processes and functions, the conceptual model, numerical models, and BRT deliberations were employed. The pathways and indicators defined in the conceptual model (see Chapter 5 of the aquatic species BA) will be used herein as a framework to discuss potential Project effects.

To investigate specific physical habitat changes (salinity, velocity, depth) that might occur after Project implementation, two numerical models, the Corps of Engineers – Waterways Experiment Station (WES) RMA-10 model and the Oregon Health Sciences University/Oregon Graduate Institute (OHSU/OGI) Eulerian – Lagrangian CIRCulation (ELCIRC) model, were used. The Service's analysis was additionally assisted by the SEI panel process, which reviewed multiple aspects of the proposed Project (historical and existing status of the lower Columbia River ecosystem; numerical modeling of hydraulic parameters; salmonid estuarine ecology; sediments and sediment quality; and monitoring and adaptive management). The aquatic species BA and its appendices (see Section 6.1.5.1 and Appendices F and G) provide a complete overview of these

analysis techniques and results of quantitative analyses and modeling outputs, and are incorporated herein by reference.

The following discussion is an analysis of the potential direct and indirect effects to coastal cutthroat trout and bull trout and their habitats from Project construction and maintenance activities, using the conceptual model indicators, and focusing on Project-related effects to key habitat types. Uncertainty regarding Project-related effects and associated risk to ecosystem indicators is discussed. Interrelated and interdependent actions, and their associated effects, are considered. Monitoring and adaptive management measures, proposed by the Corps to reduce Project-related risk and uncertainty, are discussed. A subsequent sub-section addresses potential effects resulting from proposed monitoring, ecosystem restoration, and research proposals. Finally, Service conclusions on overall Project-related effects are presented.

5.2 Uncertainty Regarding Project-related Effects and Associated Risk to Ecosystem Indicators as Related to Monitoring Actions

The SEI panel suggested that scientific and management decisions involve a level of uncertainty related to environmental effects and associated risk to the ecosystem from those environmental effects. The term "uncertainty" pertains to the amount of information available to predict a Project-related change to an indicator. For instance, if ample information for an indicator was available, the uncertainty associated with that indicator, in regards to potential Project effects, would be low.

For the purposes of these conference and consultations, the term "risk" pertains to the level of threat to the health or survival coastal cutthroat trout and bull trout from Project-related changes to indicators. For instance, if coastal cutthroat trout and bull trout are extremely sensitive to small changes in an indicator, then the risk associated with any Project-related changes to that indicator would be high. For purposes of the consultation and conference process, including BRT analysis and deliberations, each conceptual model indicator was evaluated to determine both uncertainties and risk from implementing the proposed Project activities. That information is included in the aquatic species BA (Table 7-1), and is incorporated herein by reference.

As noted below in Section 5.3 of these Service opinions, the Service believes that Project-related indirect effects to ecosystem indicators will be limited. Key physical processes that likely will have limited changes during the navigation channel construction and maintenance actions include suspended sediment, accretion/erosion, turbidity, salinity, bathymetry, and bedload. The short-term nature of those impacts were discussed during the SEI panel process and verified using the numerical modeling conducted by WES and OHSU/OGI. It should be noted that the levels of Project risk to ecosystem indicators were not high enough to require Project modification, but, due to long-term uncertainties, were still of a level to warrant verification through monitoring.

Based on uncertainties from long-term Project effects, and associated risk to salmonids, the Corps proposed a Monitoring Program (see Table 2.5, and Section 2.2.6 of these Service opinions) and the Service provided review and comment on it as part of the BRT process. The Monitoring Program addresses the long-term ecosystem uncertainties and risk to the main ecosystem indicators and key habitat features (Table 5.1) addressed in Section 5.3. Monitoring results will be reviewed, and future changes to management will occur if adverse findings were determined.

Table 5.1. Pathways and Indicators to be Addressed by the Monitoring Program

Monitoring Action	Pathway	Indicators
MA-1: Maintain three hydraulic monitoring stations to investigate pre- and post-Project relationships among flow, tide, salinity, water surface, and water temperature	Habitat-forming processes	Bedload; Salinity
	Growth	Habitat complexity, connectivity, and conveyance; Velocity Field; Feeding Habitat Opportunity
MA-2: Compare actual to predicted sediment dredge volume	Habitat-forming processes	Bedload
MA-3: Complete bathymetric surveys to track habitat alterations	Habitat-forming processes	Accretion/Erosion; Bathymetry
	Key Habitat Types	Shallow water/flats habitat
MA-4: Aerial and ground mapping to track habitat alterations	Key Habitat Types	Tidal marsh and swamp habitat
	Food Web	Suspension/deposit feeders; Insects; Tidal marsh macrodetritus
	Growth	Refugia; Habitat-specific food availability
MA-5: Contaminants monitoring team to undertake annual contaminants review activities	Survival	Contaminants
MA-6: Investigate pre- and post-Project salmonid stranding events	Survival	Stranding

5.3 Effects from Construction and Maintenance Activities

Project construction, maintenance, and effect minimization activities may have immediate (direct) effects to coastal cutthroat trout and bull trout, as well as short-term and long-term (indirect) effects to ecosystem processes and functions of importance to these species. Additional activities, interrelated to the proposed action, may also have indirect effects to coastal cutthroat trout and bull trout. The pathways and indicators from the conceptual ecosystem model are used as an analytical framework for discussing indirect effects from construction and maintenance activities. The Service believes that, if a pathway or indicator is negatively influenced by the Project, then a negative, indirect, short- or long-term impact to coastal cutthroat trout and bull trout and their habitats also may be occurring.

5.3.1 Immediate (Direct) Effects

Direct mortality to coastal cutthroat trout or bull trout from construction and maintenance activities could occur from entrainment into the dredge draghead or during in-water blasting activities.

The Service believes that any coastal cutthroat trout or bull trout entrained by the dredging activities will suffer injury or perish. Entrainment of organisms by hopper dredging has been evaluated at the mouth and in the Columbia River (Larson and Moehl 1990; R2 Resources Consultants 1999). Larson and Moehl (1990) reported that no juvenile or adult salmonids were collected during the four years of the study, even though other pelagic fish species were collected. This study concluded that, because dredging occurred below the depth where salmonids migrate, no salmonids were entrained. Documented entrainment of salmonids occurred during a research study in which the dredge draghead was purposely operated while elevated in the water column instead of within the substrate to determine presence/absence of fish. (R2 Resource Consultants 1999). This entrainment incidence level involved two salmonids. No juvenile salmonids have been entrained during monitored, normal dredging operations in the Columbia River (Larson and Moehl 1990).

The Project dredging procedures propose that the draghead and/or cutterhead will be buried, to the extent possible, in the sediment of the river bed during dredging operations. No suction will occurring through the draghead and/or cutterhead if it is raised more than three feet off the river bottom. Both these proposed "impact minimization" measures reduce the potential for coastal cutthroat trout and bull trout entrainment. Further, the Service believes that coastal cutthroat trout and bull trout are not found near deep-water dredging activities. It is believed that adult coastal cutthroat trout and bull trout have sufficient swimming capacity to avoid entrainment, and are further protected by the dredging "impact minimization" actions noted above. The Service believes that compliance monitoring, to ensure the proposed entrainment minimization

measures are implemented, will be important in minimizing any injury or death of salmonids during dredging activities.

Observations of sub-yearling and juvenile salmonid distribution and relative vulnerability to dredging entrainment impacts were conducted in the lower Columbia River (Carlson et al. 2001). Research indicated that the majority of salmonids were not utilizing the bottom of the navigation channel, where entrainment might occur during dredging activities. Analysis of hydroaccoustic sampling data revealed that, during the highest salmonid annual abundance in the lower Columbia River, only 0.0017% of those fish were adjacent to the dredging zone (within 3 ft of the navigation channel bottom) during the daylight hours, 0.0249% were adjacent to the dredging zone in the evening hours, and 0.0107% were adjacent to the dredging zone at night (Carlson et al. 2001). The combination of very limited occupancy by salmonids of deep water locations, and BMPs that restrict dredge draghead or cutterheads to be operated, to the extent possible, under the sediment surface, will ensure that entrainment of salmonids is minimized.

One location (Warrior Rock, RM 87.3) may require one-time in-water blasting. The Service anticipates blasting could injure or kill any coastal cutthroat trout or bull trout within the blasting area. However, the proposed action minimizes potential direct effects by requiring a blasting plan, using an in-water work window of November 1 to February 28 when listed trout and salmon abundances are lowest, and reducing the associated pressure wave by creating an implosion. The Service believes reducing implosion-induced over-pressure to less than 10 psi will greatly minimize blast-related impacts to coastal cutthroat trout or bull trout. However, blasting during the in-water work window minimizes, but does not avoid, direct impacts to bull trout or coastal cutthroat trout, which may use the Warrior Rock area year-round. The Service believes that development of a Service-approved monitoring plan, to ensure the proposed blasting measures are implemented, will be important in minimizing any injury or death of coastal cutthroat trout or bull trout during blasting activities.

5.3.2 Short- and Long-term (Indirect) Effects to Ecosystem Processes and Functions of Importance to Coastal Cutthroat Trout and Bull Trout

The aquatic species BA determined that, of the 38 conceptual ecosystem model indicators that might be influenced by the Project's construction, maintenance, and effects minimization activities, a total of 20 indicators of ecosystem process and function may influenced in the short- and long-term. After review of the conceptual ecosystem model (see Chapter 5 of the aquatic species BA) and the effects analysis (see Chapter 6 of the aquatic species BA), the Service analyzed five habitat forming process indicators (suspended sediment, bedload, turbidity, salinity, bathymetry) and three key habitat types (tidal marsh and swamp, shallow water and

flats, and water column) associated with physical and biological indicators that could be potentially be affected by the Project. The seven key indicators (insects, macrodetritus, microdetritus, benthic algae, deposit feeders/suspension-deposit feeders/suspension feeders, mobile macroinvertebrates, and phytoplankton) that related the prey base to coastal cutthroat trout and bull trout are integrated into the discussion of key habitat types in which they are primarily found. The habitat complexity, connectivity, and conveyance, feeding habitat opportunity, refugia, and habitat-specific food availability indicators are analyzed as a group because they can influence more than one habitat type. Thus, grouping them may better reflect an ecosystem approach to impact assessment. One additional indicator, stranding, may be caused by post-construction, deep-draft vessel traffic that is interdependent to the Project, and is discussed under 5.4 Effects from Interrelated and Interdependent Activities, below.

5.3.2.1 Ecosystem Indicator - Suspended Sediment (including an analysis of accretion and erosion)

Project dredging and disposal actions and future, interrelated activities may influence suspended sediment concentrations in the lower Columbia River, estuary, and river mouth. In areas adjacent to dredges and shoreline disposal operations, increases in suspended sediment concentrations may temporarily increase local water column turbidity (see Ecosystem Indicator - Turbidity, section 5.3.2.3 below).

Dredging operations are likely to cause downstream suspended sediment increases of zero to 2 mg/L, depending on the number and type of dredges operating. Most of the dredging and disposal-induced suspended sediment should rapidly settle onto adjacent substrates. Ocean disposal will result in longer periods of sediment suspension before the sediment settles onto the deepwater substrate. Based on data indicating that less than 1 percent of the dredged material is fine enough to remain in suspension following disposal, the Corps estimates that disposal of construction-related dredging will contribute up to 180,000 cubic yards of suspended sediments over the 2-year construction period.

Background suspended sediment loads for the same 2-year period have been estimated at four mcy. This is a maximum increase of 4.5 percent in the suspended sediment load and generally equates to less than 1 mg/L increase in suspended sediment concentrations. These volumes will have a limited influence on accretion and erosion in important salmonid habitat areas.

Contaminants associated with dredged and disposed sediments may be resuspended in the ecosystem. Contaminants are discussed below. However, much of the material to be dredged from the navigation channel will originate from existing sand waves, a dynamic natural feature of the river bottom, that are constantly moving due to river current action. These sand waves contain a small percentage of fine sediments and organic material, thus have the potential to carry a limited amount of contaminants into natural resuspension from current action or dredging and disposal.

Materials resuspended by dredging and disposal activities may accumulate within the ETM, and be redistributed into lateral habitats of importance to salmon. The effects of the deposition of additional fine sediments into lateral habitats may be beneficial to those habitats, or detrimental due to the presence of contamination. Resuspension of contaminants related to the Project are further described below. Interrelated and/or interdependent activities, such as deepening of adjacent ports and berths, can also have similar influence on suspended sediments. Ship wakes, interrelated to the Project, will cause limited increases in suspended sediment, however, the

deepened channel may result in less ship traffic and overall less ship wake-induced suspended sediment.

The Service believes that Project-related changes to suspended sediment could affect the habitat-forming process of sediment accretion and erosion. Because the Project-related slight increase in suspended sediment may increase accretion of sediment in lateral habitat areas, this Project effect will have neutral or slightly beneficial effects to habitats used by coastal cutthroat trout and bull trout. As noted above, increases in turbidity from Project activities is discussed under Ecosystem Indicator - Turbidity, section 5.3.2.3 below.

5.3.2.2 Ecosystem Indicator - Bedload (including an analysis of accretion and erosion)

Riverbed side-slope adjustments and some shoreline erosion are predicted to alter the accretion and erosion patterns within shallow water and flats habitat in the lower Columbia River at five locations – RM 99, 86, 75, 72, and 46 through 42. A single location in the estuary, RM 22.5, is projected to experience riverbed side-slope adjustments. These six locations are all historic dredge material disposal sites, and provide limited coastal cutthroat trout and bull trout habitat.

The side-slope adjustment process will take five to ten years to occur after construction. Over that time, shallow water and flats habitat at six shoreline disposal sites will tend to erode toward the shoreline and become deeper. The Corps determined that side-slope adjustments will not occur in natural shoreline areas because these riverbanks are stable, indicating that it is unlikely that tidal marsh and swamp habitat would be affected by side-slope adjustments. The Corps proposes to monitor for any impacts from side-slope adjustments to riparian habitats, including tidal marsh and swamp habitat. This information will enable the Corps and Service to track and react to potential changes in side-slope adjustment.

Sand from upstream areas is one of the sources of material for habitat-forming processes (accretion) in the estuary. This sand is important to the formation of tidal marsh and swamps and shallow water and flats habitat. The removal of sand from the river via dredging and upland disposal will not alter the ongoing, natural sediment transport process towards the estuary. The volume and rate of the bedload movement is not expected to change with Project activities. The volume of sand to be dredged over the life of the Project represents a small fraction of the total volume of sand in the riverbed. In addition, transport potential, rather than sand supply, is the limiting factor in sediment supply to the estuary. Therefore, it is likely that the impact to bedload processing of sand removal associated with the Project will be of a limited nature.

The Service believes that Project-related effects to bedload may alter potential habitat for coastal cutthroat trout and bull trout habitat at five riverine and one estuarine sites. Predicted side-slope adjustments will harm these species' aquatic habitat by alteration of shallow water, shoreline habitat. Shoreline habitats provide important feeding and rearing areas for these species, therefore any effects to these habitats, above those effects or locations predicted in the aquatic species BA, are important to monitor and address. However, these six shoreline sites are highly erosive and unstable, and do not provide high quality habitat for coastal cutthroat trout and bull trout Additional effects discussion regarding side-slope adjustment is provided below.

5.3.2.3 Ecosystem Indicator -Turbidity

Turbidity affects the ability of light to penetrate into water, and, in turn, affects the amount of plant growth that can occur. This is important for habitat development, particularly in the shallow water areas, because the plant growth adds stability and reduces the chance for erosion. Some temporary and localized changes to river and estuary turbidity levels are anticipated to occur from the Project. Localized turbidity levels from Project construction and maintenance activities, five to 26 NTUs above background levels, are not likely to produce detectable effects on plant growth in the lower river or estuary. Increased turbidity will be localized to deep water areas where dredging and in-water disposal will occur; these slight increases to natural lower Columbia River and estuary turbidity levels will occur in deeper water areas where the majority of coastal cutthroat trout and bull trout migration and feeding activities are not occurring. Local turbidity increases in shallow water areas will occur during shoreline disposal. Turbidity plumes resulting from lower Columbia River and estuary dredging and disposal occurs in a "near-field" area (Carlson et al. 2001). Increased turbidity from these Project activities are below the known turbidity levels that stimulate avoidance response by juvenile salmonids, as identified by Servizi and Martens (1992). Ocean disposal will result in localized and short-lived periods of increased turbidity. While high levels of turbidity are known to affect salmonid physiology and feeding success, the combined background and project-related turbidity concentrations are well below known salmonid impact levels (see 2001 BA sections 4 and 6.1.4).

5.3.2.4 Ecosystem Indicator - Salinity

The concentration of salinity in important habitat and rearing areas of the estuary and the longitudinal gradient of salinity between the freshwater and ocean environments that bound the estuary are important to coastal cutthroat trout growth and survival. Bull trout have not been collected in the Columbia River estuary, therefore changes to salinity are not addressed for this species. The Project will change the estuary's cross-sectional profile and have associated effects on estuary salinity gradients. Based on the WES RMA-10 and OHSU/OGI modeling, the largest Project-related impacts on salinity profiles occur at the lowest river flow analyzed (70,000 cfs).

In shallow areas of Cathlamet Bay and Grays Bay, where important coastal cutthroat trout habitat and food resources exist, the WES RMA-10 model predicted a post-Project salinity increase of 0.1 to 0.15 ppt. The OHSU/OGI model confirmed these predictions. Within the deeper navigation channel, where limited juvenile salmonid habitat and food resources exist, the WES RMA-10 model predicted post-Project salinity increases in the range of 1.0 to 1.5 ppt. The OHSU/OGI model confirmed these findings, but predicted slightly larger increases in salinity

than those predicted by WES RMA-10 modeling for Youngs Bay and along the Oregon side of the navigation channel up to Tongue Point.

Modeling runs for higher river flows indicated even smaller post-Project salinity increases in important salmonid habitats. The OHSU/OGI model also was used to determine if, post-Project, there would be a significant change in habitat opportunity, as defined by Bottom et al. (2001) and the SEI workshop process. Using the OHSU/OGI model an example of the potential changes to habitat opportunity was developed by modeling Cathlamet Bay for five one-week model simulations (see Table 6-1 of the aquatic species BA). The model predicted, for important, shallow water Cathlamet Bay salmonid habitats, there was virtually no difference in the habitat opportunity, pre- and post-Project, for salinity between 0-5 ppt.

Changes to the ETM can effect phytoplankton, nutrient cycling, and availability of coastal cutthroat trout prey primarily within the estuary. Changes in salinity as a result of the Project could result in a permanent shift in the boundaries of the ETM, of up to one mile upstream. This upstream movement will affect the location where imported phytoplankton die, and with other accumulated organic matter, are cycled through the estuary system. A change in the location and range of the ETM may affect the distribution of nutrients and thereby the location and abundance of salmonid food in shallow water habitats.

While it is believed salmonids, including coastal cutthroat trout, do not feed in the ETM, nutrient cycling from the ETM may transfer to shallow water habitats and to the food items which coastal cutthroat trout prey on. No change in type or quantity of imported phytoplankton is anticipated in the short-term, and short-term effects to coastal cutthroat trout from predicted shifts in ETM, and subsequent modification in nutrient cycling, is anticipated to be limited, and will not harm coastal cutthroat trout. However, long-term impacts of the predicted shift in the ETM, based on potential changes to phytoplankton and nutrients (see Table 7-1 of the aquatic species BA) over the Project's life are uncertain. The Service believes the Corps' proposed Columbia River ETM workshop should enhance the understanding of the ETM and its influence on estuary ecosystem function. Workshop findings will be discussed within the Adaptive Management Process for the Project. Project modifications may then be implemented, as necessary, to minimize Project-related effects to the ETM.

5.3.2.5 Ecosystem Indicator - Bathymetry (including an analysis of velocity field)

Bathymetric changes will occur in and adjacent to the navigation channel. Dredging will lower the riverbed by three feet, in and adjacent to the navigation channel. Long-term riverbed adjustments will occur on adjacent side slopes (see Section 5.3.2.2, above). Within the riverine areas, 60

percent of the navigation channel will require deepening, whereas only 45 percent of the navigation channel in the estuary reach will require dredging. In-water and shoreline disposal of dredged materials will cause bathymetric changes by raising river and ocean bed elevations at disposal sites.

The deepened navigation channel will result in a small effect (decrease of up to 0.18 feet) on Columbia River water surface elevations in the upper Project area, essentially immeasurable decrease (0.02 feet) in water surface elevation in the estuary, and no water surface elevation change in the river mouth reach. These water surface elevations should not impact existing habitats or reduce the ability of coastal cutthroat trout or bull trout to access those habitats. Also, within the upper river portion of the Project, lower water levels may allow marsh progradation (i.e., building out) waterward of the marsh.

The OHSU/OGI model evaluated pre-and post-Project water depth differences in terms of hours of habitat opportunity. The model outputs for important, shallow water Cathlamet Bay salmonid habitats are nearly identical for pre- and post-Project water depths, indicating effects of the proposed action on the water depths will have a limited impact on habitat opportunity.

Changes in bathymetry from dredging and disposal may change river velocity, and thereby affect habitat opportunity. The WES RMA-10 modeling results indicated that average pre- and post-Project velocity differences are small, ranging from approximately -0.2 foot per second to 0.2 foot per second. The largest velocity differences were noted in the navigation channel, and are within the normal velocity range commonly encountered by coastal cutthroat trout and bull trout.

Pre- and post-Project velocity differences in shallow salmonid habitat areas outside the navigation channel ranged from approximately -0.05 to 0.05 foot per second. OHSU/OGI modeling supports these results. The post-Project velocities are well within the range of favorable velocities identified for juvenile salmonids, as defined by NMFS (Bottom et al. 2001). The Service believes these post-Project values are favorable velocities for all life stages of coastal cutthroat trout using these shallow water habitats. The OHSU/OGI model evaluated pre- and post-Project velocity magnitude differences in terms of hours of habitat opportunity. Modeling results were done for vertically averaged water column velocities and for minimum and maximum water column velocities. Both the spatial distributions and the area-weighted averages for water column velocity were similar for pre- and post-Project. Maximum differences in average hours of approximately ten to 15 percent (increase and decrease) between base and plan were predicted for model runs at both low and high flow. In these cases, the model runs for the post-Project scenario estimated higher habitat opportunity hours than the environmental baseline.

Based on the impacts to water depth-associated habitat opportunity, the Service concludes that there will be a limited, short-term effect on feeding habitat opportunity or refugia for coastal cutthroat trout and bull trout. In particular, the changes in water surface elevations projected within the estuarine and riverine reaches are not likely to alter the amount or location of refugia. In addition, changes to river current velocity from the proposed dredging are anticipated to be small (particularly in the side channels and shallow water areas that provide the refugia) and will not affect the function of the available refugia.

While short-term impacts appear to be unlikely, the long-term impacts to habitat opportunity and refugia for coastal cutthroat trout and bull trout over the Project's life from these limited bathymetric and hydraulic changes cannot be quantified and are therefore uncertain. Any long-term, negative changes in bathymetric or hydraulic conditions may harm these species' aquatic habitat, thereby negatively effecting refugia and habitat opportunity for these species. Therefore any effects to these habitat conditions, above those effects or locations predicted in the aquatic species BA, are important to monitor and address via the Adaptive Management Process.

5.3.2.6 Effects from Construction and Maintenance Activities on Key Salmonid Habitats

During the course of this consultation and conference, much discussion centered around the potential effect of construction and maintenance activities on tidal marsh and swamp, shallow water and flats, and water column habitats. The conceptual model identified these habitat types as being important, in particular, to coastal cutthroat trout residing in the estuary. The Service provides a detailed examination of these three key habitat types, and summarizes the Project-related effects to the key habitat type at the end of each sub-section.

5.3.2.7 Tidal Marsh and Swamp

Tidal marsh and swamp habitat occurs sporadically along the margins of shallow water areas of the Columbia River and estuary, with these habitats' most concentrated occurrence in the estuary and downstream portions of the riverine reach. The Service believes these shallow, complex, productive habitats are important to all life stages of coastal cutthroat trout. Bull trout, if present in the lower Columbia River, are not believed to use these shallow water habitats. No dredging or disposal within the tidal marsh and swamp habitat is planned, therefore no direct loss of tidal marsh and swamp habitat from the Project is anticipated. The Service, in analyzing potential Project effects to tidal marsh and swamp, focused on Project-related effects to the habitat-forming processes of salinity and bathymetry, and also reviewed Project effects to ecosystem indicators that would respond to changes in habitat .

Based on the WES RMA-10 and OHSU/OGI model outputs, the post-Project salinity distribution is unlikely to change within shallow water estuary areas, where much of the tidal marsh and swamp habitat is located. In addition, even if larger post-Project salinity changes occur in the estuary than were predicted by the models, the dominant marsh plants found in these habitats exhibit wide salinity tolerances. In upriver areas, tidal marsh and swamp habitats will not be influenced by any post-Project changes to salinity distribution, as these habitat features are upstream of salt water influence.

The other major habitat-forming process that may influence tidal marsh and swamp habitat is bathymetry. Predicted post-Project water surface elevation changes range from zero to -0.18 foot, with the smallest elevation changes predicted in the estuary and lower river areas. In fact, tidal marsh and swamp habitat may increase slightly in upriver Project areas as a result of the channel deepening. The predicted decrease in water surface elevation in upriver areas may provide more shallow water habitat that is at the appropriate depth for tidal marsh to develop. This would allow tidal marshes to establish or expand, and may lead to a long-term, small increase in tidal marsh habitats.

The Corps determined that side-slope adjustments will not occur in natural shoreline areas because these areas are stable, indicating that it is unlikely that tidal marsh and swamp habitat would be affected by post-Project side-slope adjustments. The Corps proposes to monitor for any impacts from side-slope adjustments to riparian habitats, including tidal marsh and swamp habitat. This information will enable the Corps and the Service to track and react to potential changes in side-slope adjustment.

The following are the two specific environmental indicators that could be affected by changes to tidal marsh and swamp habitats:

5.3.2.7.1 Insects

Terrestrial insects form part of the prey base for coastal cutthroat trout. Insect larvae and some adults insects are often found in the stomachs of coastal cutthroat trout that feed in shallow flats and marsh channels. Salinity intrusion, associated primarily with the main channel, is not expected to change the abundance of insects that are located primarily along the water margins in shallow wetlands and marsh channels.

Short-term impacts to insect abundance and diversity are likely to be limited. Based on Table 7-1 of the aquatic species BA, the uncertainty and risk of impact to insect production and salmonid food availability, although potentially limited, is uncertain in the long term. Long-term

monitoring, as recommended above for areas of side-slope adjustment, will provide information on Project-related effects to insect production.

5.3.2.7.2 Macrodetritus and Microdetritus

The production of prey resources important to coastal cutthroat trout is partially supported by marsh detritus. Resident microdetritus, which is derived from benthic and planktonic algal production, is important to suspension feeders and suspension/deposit feeders. Imported microdetritus is mostly derived from algal production upriver, including that produced above dams. As a primary producer, it is an important food source for suspension feeders and suspension/deposit feeders that form part of the prey base for coastal cutthroat trout.

The proposed dredging action is not likely to have an effect on the amount or productivity of tidal marsh macrodetritus or microdetritus. This is because no dredging or disposal within the tidal marsh and swamp habitat is planned.

Due to the predicted lowering of water elevation in the upper portion of the Project area, the amount and characteristics of tidal marsh and swamp habitat could result in limited expansion along the shallow water margins of the upper Project area. Increased macrodetritus and microdetritus production may occur from limited marsh expansion upstream of RM 80. Due to the predicted upstream shift of the ETM, there may also be a limited shift in the extent of resident and imported microdetritus food web input. The Project may also result in a small shift in the location of where resident microdetritus dies. Thus, short-term impacts to macrodetritus and microdetritus are likely to be limited. Based on Table 7-1 of the aquatic species BA, the risk and uncertainty to this indicator suggests the limited nature of this expansion will have an uncertain benefit to coastal cutthroat trout in the long-term.

5.3.2.7.3 Tidal Marsh and Swamp Summary

The Service anticipates negative short-term Project-related effects to tidal marsh and swamp habitats will be limited. Long-term Project effects to tidal marsh and swamp habitats are of moderate uncertainty, but low risk to adverse habitat modification (see aquatic species BA, Table 7-1). Any long-term, negative changes in tidal marsh or swamp habitat may harm coastal cutthroat trout feeding and refugia needs. Therefore any effects to these habitat conditions, above those effects or locations predicted in the aquatic species BA, are important to monitor and address.

5.3.2.8 Shallow Water and Flats

Shallow water and flats habitats provide important feeding and rearing areas for various life stages of coastal cutthroat trout and migratory bull trout. The Service, in analyzing potential Project effects to shallow water and flats habitats, focused on Project-related effects from side slope adjustments after channel dredging and after shoreline disposal, and also reviewed Project effects to ecosystem indicators that would respond to changes in shallow water and flats habitat.

The entire post-Project navigation channel may experience side-slope erosion and subsequent adjustment of side-slope angle. The erosion and adjustment will, over five to ten years, lower the adjacent river bed angle until a new, more stable side-slope is established. While side-slope adjustments will occur throughout the Project area in deeper water, where minimal salmonid habitat use is known to occur, some side-slope adjustment will occur in shallow water and flats habitats.

The Corps predicts shoreward erosion from side-slope adjustment to occur in a total of six sandy beach areas: five in the lower Columbia River (RM 99-86, 75, 72, and 46-42) and one in the estuary (Miller Sands Spit). These areas have shallow water habitats that could be used by coastal cutthroat trout and bull trout, however, the Corps indicates these are highly erosive areas that have little productivity.

The Service believes that, even though each of the six sandy beach sites may experience 10 to 50 foot lateral erosion into the sandy shoreline, minimal impact to coastal cutthroat trout and bull trout or their shallow water habitat will occur. As noted in 5.3.2.2, Ecosystem Indicator - Bedload, above, predicted side-slope adjustments will harm habitat for coastal cutthroat trout and bull trout by alteration of these six areas with shallow water, shoreline habitat. Shallow water habitats provide important feeding and rearing areas for coastal cutthroat trout and bull trout, therefore any effects to these habitats, above those effects or locations predicted in the aquatic species BA, are important to monitor and address. However, these six shoreline habitats are highly erosive and unstable, and do not provide high quality habitat for these species.

Shoreline disposal could potentially disturb and shift the location of shallow water habitat at three proposed shoreline disposal sites. No coastal cutthroat trout and bull trout will be injured during shoreline disposal activities, as dredged materials are discharged above the water line. Therefore, the Service's analysis focused on the potential for disturbing coastal cutthroat trout and bull trout that use existing shallow water habitat within these areas. The three shoreline disposal locations have steep side slopes (around ten percent) that provide about seven acres per mile of shallow water areas. Shoreline disposal will affect a total of about 4.5 miles or 30 acres of shallow water. While 30 acres of shallow water habitats will be periodically impacted during the project life, the three disposal sites are all highly erosive and do not contain many of the

important habitat features that shallow water habitats typically include, such as low velocity, vegetation, and food sources. These sites had previously been approved by NMFS for shoreline disposal because of their low productivity.

The following is the one specific environmental indicator that could be affected by changes to shallow water and flats habitats:

5.3.2.8.1 Benthic Algae

Benthic algae consist primarily of benthic diatoms that occur on sediment grains and larger inorganic material and on macrophytes as epiphytes.

There will be no dredging in the shallow flats and channels where benthic algae primarily occur. Flowlane disposal is not expected to affect benthic algae because it is done below the depth range where benthic algae occur, about 1 meter below MLLW. No dredging or disposal activities are proposed for areas with significant benthic production. The closest potential effect would be from the shoreline disposal at Sand Island (O-86.2). However, the existing currents and erosion rates at the beach nourishment site create a coarse-grained and erosive environment that severely limits the potential for significant benthic production. Accordingly, no effects to benthic production are anticipated in the riverine reach.

Modeling by OHSU/OGI and WES predicts an upstream shift of salinity of less than a mile. Accordingly, there may be an upstream shift in the location of benthic algae production. Any salinity change would occur primarily in the navigation channel, not in productive side channels or lateral habitats. Thus, short-term impacts to benthic algae are likely to be limited. However, long-term Project-related indirect impacts are uncertain (see Table 7-1 of the aquatic species BA). The Service believes long-term risk to food web production for coastal cutthroat trout and bull trout, based on changes to benthic algae production, is limited.

5.3.2.8.2 Shallow Water and Flats Summary

The Service anticipates negative short-term Project-related effects to shallow water and flats habitats will be limited to areas of side slope adjustment and shoreline disposal. Long-term Project effects to shallow water and flats habitats are of moderate uncertainty, with low to moderate risk to adverse habitat modification (see aquatic species BA, Table 7-1). Any long-term, negative changes in shallow water and flats habitat may harm benthic production, feeding, migration, and refugia needs for coastal cutthroat trout and bull trout. Therefore any effects to these habitat conditions, above those effects or locations predicted in the aquatic species BA, are important to monitor and address via the Adaptive Management Process.

5.3.2.9 Water Column

Coastal cutthroat trout have been mainly collected at shallower depths in the naturally-turbid lower Columbia River, estuary, and river mouth. This species is known to use a variety of habitats, including shallow and deep water habitats in other rivers (Giger 1972). The Service believes this species occupies the mid- to upper portion of the lower Columbia River, estuary, and river mouth's water column habitat for movement, migration, and feeding, but also may use deeper water areas. Migratory bull trout, a sight-feeder, also may use the upper water column in the lower Columbia River, where better visibility occurs. Deeper water column habitat in the lower Columbia River, estuary, and river mouth is less used by salmonids, with water deeper than 20 feet believed to be rarely used. Water column habitat adjacent to the navigation channel, turning basins, and berths will be increased to no more than 48 feet deep. The Project may affect water column habitat by a short-term blasting activity, by temporary water clarity reduction during dredging and flowlane disposal activities, and by long-term changes in estuary salinity distribution and ETM range.

Blasting will be done once during Project construction, and will occur only during the in-water work window, following a blasting plan that minimizes impacts to aquatic species. Blasting may have direct effects to coastal cutthroat trout and bull trout, and was discussed in Section 5.3.1 of these Service opinions, Direct Effects. Blasting during the in-water work window minimizes, but does not avoid, direct impacts to coastal cutthroat trout and bull trout, which may use the Warrior Rock area year-round. As noted in Section 5.3.1 above, Direct Effects, the Service believes that development of a Service-approved monitoring plan, that ensures that the proposed blasting measures are implemented, will be important to minimize any injury or death to coastal cutthroat trout and bull trout during blasting activities.

Temporary water clarity reductions will occur from dredging and disposal activities. A proposed impact minimizing action will require all in-water disposal activities, except shoreline and two ecosystem restoration features, to occur below 20 feet in depth, where less coastal cutthroat trout and bull trout use occurs. Ecosystem restoration features at Miller-Pillar and Lois Island embayment are the ecosystem restoration exceptions to the minimization proposal. Effects from ecosystem restoration activities are addressed in Effects Resulting from Proposed Monitoring, Ecosystem Restoration, and Research Proposals section, below. As noted in the Turbidity discussion above, these temporary turbidity increases will not decrease plant growth and subsequent habitat forming processes. However, Project-related turbidity levels may harass coastal cutthroat trout and bull trout by limited impacts to these fishes' physiology and feeding. Although Project construction and maintenance activities may occur outside of the normal November 1 to February 28 in-water work period, and therefore increase turbidity during periods of highest coastal cutthroat trout and bull trout abundance in the Project area, coastal cutthroat trout and bull trout use occurs primarily at depths shallower than 20 feet, and so would not be expected to be impacted by turbidity from dredging and disposal operations. The Service believes these slight increases to natural Columbia River and estuary turbidity levels will occur in deeper water areas where the majority of coastal cutthroat trout and bull trout migration and feeding activities are not occurring, therefore these species should experience only limited harm from increased water column turbidity.

As noted in the ETM and salinity discussions above, the WES RMA-10 and OHSU/OGI models predicted that there was virtually no difference in the habitat opportunity (i.e., salinity "accumulation") between pre- and post-Project modeling runs for important shallow water Cathlamet Bay salmonid habitats, including those used by coastal cutthroat trout. However, a shift in the location of the ETM would occur and may affect the estuarine distribution of nutrients and thereby the location and abundance of coastal cutthroat trout food in shallow water habitats. The risk and uncertainty to the ETM, based on changes in salinity (Table 7-1 of the aquatic species BA), is low in the short-term, but more uncertain in the long-term because of extrapolating modeling results over the life span of the Project.

The following are the three specific environmental indicators that could be affected by changes to water column habitats:

5.3.2.9.1 Deposit Feeders/Suspension-Deposit Feeders/Suspension Feeders

Limited removal of organisms via dredging and burying of deposit feeders, suspension/deposit feeders, and suspension feeders will occur in portions of the navigation channel deep water areas and the three shoreline disposal sites. Flowlane disposal will bury some animals and, if

deposition of sediments is heavy, will result in the partial loss of some communities. Removal and burial effects are expected to be relatively short-lived, with dredge and disposal areas being recolonized by deposit feeders. Deposit feeders occur in low densities in the navigation channel because the sand waves create constantly shifting habitat conditions. In these and other areas of the river, densities fluctuate as a result of constantly changing environmental conditions. No changes to deposit feeders are anticipated in shallow water areas, side channels, or embayments, which are the important locations for salmonid feeding opportunities. Other than the low risk identified to deposit feeders in the bottom of the navigation channel, Table 7-1 of the aquatic species BA suggests that the long-term changes from dredging and disposal to deposit feeders, suspension/deposit feeders, and suspension feeders is uncertain. Because deposit feeders, suspension/deposit feeders, and suspension feeders are prey items for coastal cutthroat trout and bull trout, any removal of these organisms via dredging or disposal may cause short-term harm to these fish species. However, because the loss of food items is limited, will not occur in the most important habitat types, and these invertebrates recolonize dredge and disposal locations rapidly, the Service believes this harm is minimized.

5.3.2.9.2 Mobile Macroinvertebrates

Dredging will result in removal of mobile macroinvertebrates in the channel. Entrainment by dredges is likely lethal to macroinvertebrates. In addition, flowlane disposal may temporarily bury some animals and, if deposition of sediments is heavy, will result in the loss of some members of the group. Removal and burial effects are expected to be relatively short-lived, with dredged areas being recolonized within six to 12 months (Flemmer et al. 1997). Mobile macroinvertebrates located in shallow water, flats, and tidal marsh channels are not likely be affected. Coastal cutthroat trout and bull trout may feed on certain mobile macroinvertebrates, and therefore any loss of these prey items via dredging or disposal may harm these species. However, the Service anticipates this harm from dredging or disposal to be localized to areas of low importance to these species.

Mobile macroinvertebrates in the estuary appear to be adapted to respond rapidly to disturbances and can recolonize areas following these disturbances. Due to this group's wide salinity tolerance, Project-related changes in estuary salinity are not expected to have an effect on the distribution of mobile macroinvertebrates. In addition, since Project-related temperature and suspended sediment changes are not anticipated or will be limited in nature, mobile macroinvertebrates should not be influenced by limited Project-related changes to these indicators.

5.3.2.9.3 Phytoplankton

Because salinity may intrude farther into the estuary as a result of the deeper channel depth, the point where imported phytoplankton contact dilute seawater will be farther upstream from current conditions. Predicted changes in salinity intrusion may affect the location of resident phytoplankton productivity. Based on Table 1 of the aquatic species BA, the short-term impacts to imported and resident phytoplankton productivity changes are likely to be limited, and will not harm coastal cutthroat trout and bull trout. However, long-term impacts over the Project's life, based on the BRT's risk and uncertainty analysis, are uncertain.

5.3.2.9.4 Water Column Summary

The Service anticipates negative, short-term Project-related effects to water column habitats will be limited to blasting areas and areas where in-water disposal is occurring, and to ecosystem indicators associated with inwater disposal. The Service believes that development of a Service-approved monitoring plan that ensures that the proposed blasting measures are implemented, will be important to minimize any injury or death of coastal cutthroat trout and bull trout during blasting activities. The Service believes that only limited harassment from increased water column turbidity will occur to coastal cutthroat trout and bull trout. Removal of deposit feeders, suspension/deposit feeders, suspension feeders, and mobile macroinvertebrates via dredging or disposal activities may cause short-term harm to coastal cutthroat trout and bull trout. Long-term Project effects to water column habitats are of moderate uncertainty, with low risk to adverse habitat modification (see aquatic species BA, Table 7-1). Any long-term, negative changes in water column habitat may harm feeding, migration, and refugia needs of coastal cutthroat trout and bull trout. Therefore any effects to these habitat conditions, above those effects or locations predicted in the aquatic species BA, are important to monitor and address via the Adaptive Management Process.

5.3.2.10 Indicators that Occur in More Than One Key Habitat Type

During informal consultation, consideration was given to whether the proposed Project has the potential, based on post-Project changes in water surface elevation, velocity, and salinity intrusion, to change habitat complexity, connectivity, or conveyance; feeding habitat opportunity; refugia; and habitat-specific food availability associated with tidal marsh and swamps and shallow water and flats habitat areas. These are indicators that may respond to Project-related changes in any of the key habitat types, and therefore reflect an ecosystem approach to impact assessment.

The Corps undertook modeling to examine the potential Project effects on habitat opportunity and key habitat types from changes in water surface elevation, velocity, and salinity intrusion.

The OHSU/OGI and WES RMA-10 modeling results indicate slight changes to water surface elevation, velocity, and salinity intrusion. Within Cathlamet and Grays Bays' tidal marsh and swamps and shallow water and flats habitat habitats, modeling predicted post-Project salinity increases of 0.1 to 0.15 ppt, velocity decreases of 0.05 feet per second, and depth changes of less than 0.02 feet. Habitat opportunity, based on a combined analysis of these indicators, shows no significant difference between pre- and post-Project conditions in tidal marsh and swamps and shallow water and flats habitats. The OHSU/OGI modeling also related these physical parameters to the concept of habitat opportunity (see Bottom et al. 2001). In the modeling example provided by OHSU/OGI, navigation channel improvements are predicted to result in a limited change in habitat opportunity hours for Cathlamet and Grays Bays, based on the depth and velocity criterion and salinity "accumulation."

The two indicators most related to habitat opportunity are feeding habitat opportunity and refugia (see Chapter 5 of the aquatic species BA). Additional indicators related to habitat opportunity are habitat complexity, connectivity, and conveyance; and habitat-specific food availability. Based on the limited impacts indicated by the OHSU/OGI habitat opportunity modeling results, the Service believes the Project will have limited short-term effects on tidal marsh and swamps and shallow water and flats habitat habitats. Limited effects to these key habitats should result in limited effects to associated habitat complexity, connectivity, and conveyance; feeding habitat opportunity; habitat-specific food availability; and refugia for coastal cutthroat trout and bull trout. The Service anticipates limited harm to coastal cutthroat trout or bull trout from changes to habitat opportunity and associated indicators.

Model-generated estimates of habitat opportunity provide an indication of limited change to depth, velocity, and salinity within key habitat types (tidal marsh and swamps and shallow water and flats habitat habitats), but does not predict response by key habitat or other related indicators' to Project-related changes in depth, velocity, and salinity over the long-term. This fact, combined with the risk and uncertainty indications provided in Table 7-1 of the aquatic species BA for habitat opportunity-related indicators, suggest that the long-term impact to these indicators is uncertain. The Service believes any effects to these habitat conditions, above those effects predicted by modeling or presented in the aquatic species BA, are therefore important to monitor over longer time scales and address via adaptive management.

5.3.2.11 Contaminants

Dredging and in-water disposal activities in the navigation channel, turning basins, and berths, and in-water disposal activities in the ocean, along with other natural and anthropogenic processes, could expose salmonids to some contaminants. Of particular concern is resuspension of

persistent organochlorine contaminants including total polychlorinated biphenyls (PCBs) and the pesticide DDT and its metabolites DDE and DDD ($\sum$DDTs), which have bioaccumulated in resident fish and wildlife within the estuary (see terrestrial species Opinion for further description of these concerns). In addition, petroleum compounds, characterized as total polyaromatic hydrocarbons (PAHs), have been identified in lower Columbia River sediments. The organochlorine and PAH contaminants have the ability to impact growth, survival, and reproduction of juvenile salmon and trout, and can cause sublethal effects such as immune dysfunction (Arkoosh et al. 1991; also see aquatic species BA, Appendix B for further discussion of lethal and sublethal impacts of these chemicals on salmonids). Data collected by NMFS indicate that juvenile salmonids within the Columbia River estuary have contaminant body burdens that may already be within the range where sublethal effects may occur, although the sources of exposure are not clear (NWFSC Environmental Conservation Division 2001).

Data are sparse regarding the exact pathways for uptake and bioaccumulation of contaminants by juvenile salmonids in the lower Columbia River, or the relationships between sediment and tissue contamination (see aquatic species BA Appendix B for identification of specific pathways for salmonids). Recent studies suggest that sediments are a major source of hydrophobic contaminants to aquatic biota (Zaranko et al. 1997, Maruya and Lee 1998). In sediments, contaminants are adsorbed to the organic carbon in silt, which is part of the fine particulate fraction. The microbial biofilm that accumulates on the surface of organic particles constitutes the food of certain types of epibenthic invertebrates; together, they make up the pathway by which these contaminants enter food chains involving juvenile salmonids. Thus, juvenile salmonids bioaccumulate organochlorine contaminants and PAHs principally from their food (i.e., epibenthic prey species) as opposed to water. NMFS has documented some contaminants in the epibenthic prey species of juvenile salmonids in the lower Columbia River (NWFSC Environmental Conservation Division 2001).

In order to adequately address the potential contaminant-related impacts from Project activities, it is important to assess the amount of fine-grained (and thereby potentially-contaminated) material retained in the estuary following dredging and disposal activities. According to the aquatic species BA, the Columbia River navigation channel is dominated by course-grained materials (primarily sand) with very low organic carbon, although pockets of fine materials are occasionally encountered, such as within the turning basin at Astoria, Oregon. The navigation channel is characterized by sand waves along the riverbed that move downstream. As the downstream sand movement occurs, bedload transport erodes sand from the upstream face, deposits in the downstream trough, and then buries it with more sand eroded from the upstream face. This transport occurs in a layer only a few sand grains thick. The sand that forms the cutline shoals or sand waves is repeatedly re-exposed to the water column. Consequently, fine

material mixed in with the sand is likely to be swept away as the layers are exposed to the river currents, resulting in the limited potential for release of fines during the dredging activity. The Corps employed a risk-based analysis (see Appendix B of the aquatic species BA) to address the potential resuspension of contaminants (total PCBs, $\sum$DDTs, and total PAHs) produced by Project construction and maintenance activities. The results of the Corps' assessment concluded that contaminant concentrations in the navigation channel sediments posed only negligible risk to juvenile salmonids, whereas some nearshore sediments closest to point sources of contamination posed risks.

It is important to ensure that sufficient sediment samples are available to adequately characterize the nearshore and channel sediment. During their Sediment Quality Evaluation for the Project, the Corps reported 3 of 23 samples chemically analyzed within or near the navigation channel contained fine-grained sediments with detectable levels of DDT, DDE, DDD, and total PCBs. However, none of these samples exceeded DMEF contaminants thresholds. These data and other sediment data were evaluated in the risk assessment for salmonids (see Appendix B of the aquatic species BA), which concluded that sediments from the navigation channel pose negligible risks to salmonids. However, this Appendix B conclusion was based on relatively few sediment samples collected within the navigation channel, especially below RM 40. The Corps has subsequently submitted additional analysis of all available sediment and contaminants data from the Columbia River navigation channel (Corps' April 22, 2002 addendum). The Corps has determined there are no navigation channel sediment and contaminants data which exceed current DMEF contaminants thresholds. These additional data also do not exceed NMFS' thresholds for PCB's (for 75 ng/g dry weight for 1% total organic carbon TOC) and PAH's (1,000 ng/g dry weight sediment) (J. Buck, pers. comm.).

Due to the highly erosive and dynamic nature of the navigation channel, described above, new data contained in the Corps April 22, 2002 addendum, and the Corps' risk analysis results and information provided in Appendix B of the aquatic species BA, the Service believes it unlikely that any contaminants within the navigation channel would be present in high enough concentrations to expose and impact coastal cutthroat trout and bull trout. However, it is unknown how much fine material will be resuspended during Project dredging and disposal activities, or whether or not any of the fine material released would be contaminated. The general lack of organic material and very low organic carbon concentrations in the navigation channel sediments would likely result in rapid transfer of any available carbon and contaminants into salmonid tissues. Even low concentrations of bioaccumulative contaminates would be readily available to salmonids in this situation, and predators higher in the food chain, such as bald eagle, could be more at risk than salmonids. The Service's heightened concern for bald eagle, which has an elevated risk of effect from bioaccumulation of contaminants, is reflected in the Service's

terrestrial species Opinion. Therefore, the Service believes additional navigation channel samples should be periodically collected, and all other new sediment quality data evaluated, on a regular basis, during Project activities to better determine the distribution of fine materials, carbon, or contaminants within the navigation channel.

In summary, the Service believes that dredging and inwater disposal activities associated with the Project could release a small amount of fine-grained sediments. It is uncertain as to whether most of these fine-grained sediments would be uncontaminated (due to the erosional forces within the main channel of the river), or if some of the fine-grained material would be associated with contaminants. In the high-energy environment of the navigation channel, any contaminated material would move rapidly through the system and be deposited outside the flow lane in depositional areas within the estuary, or be transported down the flow lane and into the ocean. Any contaminants that did reach riverine and estuarine depositional areas, combined with contaminants transported and deposited due to natural and other non-Project anthropogenic sources, would eventually be redistributed, resuspended, and transferred along the estuary and river food chain.

The contribution of Project activities to contaminant burdens in salmonids is not well defined and, as such, some uncertainty exists as to Project effects to coastal cutthroat trout and bull trout. The Service therefore supports implementation of the Corps' contaminants research activities ERA-4 and ERA-5, proposed in the aquatic species BA (see Table 8-1) and monitoring action MA-5, proposed in the aquatic species BA (see Table 7-3). However, the Service believes estimated risk of exposure of coastal cutthroat trout and bull trout from contaminated sediments from Project activities appears limited (see Appendix B of the aquatic species BA).

5.4 Effects from Interrelated and Interdependent Activities

5.4.1 Willamette River Navigation Channel Deepening

More than 11 miles of the Willamette River are included in the Project authorized by Congress but are not analyzed in the aquatic species BA or these Service opinions. Concerns over Willamette River sediment contamination and uncertainty regarding the scope and timing of remedial investigations and actions caused the Corps to remove this portion from the proposed action. Potential effects from any future, Willamette River Navigation Channel deepening activity cannot be determined, due to the unknown implications of Superfund cleanup and other remedial actions. If the Corps is to proceed with a Willamette River navigation channel deepening project in the future, the Corps will be required to review the additional effects of future federal action through a separate Act consultation process.

5.4.2 Deepening and Maintenance of Project Berths

Construction and maintenance dredging at a total of seven lower Columbia River berths, associated with three grain facilities, one gypsum plant, and one container terminal, represent actions that are interrelated and/or interdependent to the Project. However, these Service opinions do not provide incidental take coverage for berth dredging, as these activities will undergo future Act consultation. The future Act consultation will initiate upon the Service's receipt of applications for Federal permits, prior to berth dredging activities.

Future berth deepening and maintenance activities are likely to have both direct and indirect impacts on coastal cutthroat trout and bull trout. Direct effects include death or injury due to entrainment during dredging activities. Indirect effects include harm and harassment to coastal cutthroat trout and bull trout via increased turbidity, loss of food resources, and resuspension of contaminants in sediments.

Effects from future berth deepening activities will be minimized due to application of dredging and disposal BMPs and other compliance measures (see Table 2.1 of these Service opinions). Sediment testing, based on DMEF protocols, will ensure dredged materials from berths are disposed in the least impactful method. Additional sediment testing may be required by NMFS and the Service (see discussion of MA-5 in section 3.2.6 of these Service opinions). Dredging activities will occur within the November 1 to February 28 inwater timing window, when coastal cutthroat trout and bull trout abundance is lowest. Dredge activities will occur in deep water, where food resources are limited and most salmonids are not present. Finally, higher quality habitat, associated with key habitat types in the ecosystem conceptual model, are not believed to occur at these existing berth features, and therefore impacts to these habitats will be avoided.

The Service believes berth deepening and maintenance will have limited future adverse effects on coastal cutthroat trout and bull trout. While some of these adverse effects can be successfully minimized by application of BMP's and compliance measures, a limited amount of harm and harassment of coastal cutthroat trout and bull trout is likely to occur from berth deepening and maintenance activities. These berth deepening and maintenance activities will undergo future Act analysis and consultation prior to berth dredging activities to address this incidental take of coastal cutthroat trout and bull trout.

5.4.3 Development of Port Activities and Deep Draft Vessels

Based on the Corps' 1999 FEIS analysis, future development of other lower Columbia River port facilities is not analyzed here as an interrelated or interdependent activity because such

development will be caused by regional market factors such as commodity demand, not by channel improvements. The Corps' April 15, 2002, addendum further supports the Corps' FEIS conclusion that, aside from berth deepening, potential future port development is not interrelated or interdependent with the Project.

Impacts from interdependent ship wakes would occur only if the Project resulted in more frequent or larger, higher-energy ship wakes. Current impacts from shallow- and deep-draft ship traffic utilizing the 40 foot navigation channel are considered part of the environmental baseline and are not considered interrelated or interdependent to the Project; only future, Project-dependent ship traffic is considered in this analysis.

The Corps analysis of post-Project ship wake effects indicated that larger, fully-loaded ships would have a 1-5 percent increase in "blockage ratio" (indicative of slightly higher ship wake generation), whereas smaller vessels would have a 1-5 percent decrease in "blockage ratio" (indicative of slightly lower ship wake generation). The Service concludes that these limited increases and decreases in post-Project ship wake are not likely to increase suspended sediment, shoreline erosion, or increase current rates of ship wake-induced salmonid stranding.

In summary, the Corps concluded in their 1999 FEIS that channel deepening will not induce additional ship traffic, or contribute to development of additional port infrastructure or new ports. This conclusion is consistent with historical vessel traffic trends on the Columbia River and with the market forces that drive port facility development.

5.4.4 Non-indigenous Species Introductions

Several non-indigenous aquatic species are believed to have been introduced into the Columbia River via ballast discharge (e.g., asian clam). These non-indigenous species introductions may continue to occur from ongoing vessel traffic, regardless of the Project's deepened channel. Future deep-draft cargo vessel traffic, interrelated and/or interdependent to the deepened navigation channel, also may introduce additional non-indigenous species. Federal authority for management and regulation of exotic species via ship ballast resides with the U.S. Coast Guard. While the Service believes additional non-indigenous species introductions could have detrimental impacts on Columbia River and estuary ecosystem resources, the Service does not believe that new boat traffic, interrelated and/or interdependent to the deepened navigation channel, will increase the risk of introduced species above current baseline levels.

5.4.5 Summary

If new information is identified which changes the assumptions and/or conclusions of the 1999 FEIS or aquatic species BA regarding the potential for future interrelated and interdependent Project actions, the Corps will need to reinitiate Project consultation to address those activities. Additionally, no other non-Project activities within the lower Columbia River, estuary, or river mouth have been reviewed in this effects analysis. Therefore, any additional actions to deepen or otherwise improve adjacent port facilities not addressed in this Project consultation and conference, would be subject to separate environmental analysis and regulatory review.

5.5 Effects Resulting from Proposed Monitoring, Ecosystem Restoration, and Research Activities

The BRT has identified the monitoring, research and ecosystem restoration components of the proposed action to verify assumptions, reduce scientific uncertainties and provide for long-term beneficial effects to coastal cutthroat trout and bull trout and their important habitats. Substantial scientific information suggests that certain habitat types play a major role in the long-term viability of salmonid populations, including tidal marsh and swamp habitats; shallow water and flats habitats; and water column habitats. The Corps therefore has identified a number of restoration actions that have a high probability of enhancing the availability and productivity of these habitats for salmonids within the Project area. Nevertheless, the implementation of these restoration actions and the implementation of the monitoring and research actions will likely have short term detrimental impacts of limited scope and duration to salmonids .

This section reviews the effects of these components of the proposed action on coastal cutthroat trout and bull trout. The Service notes the difficultly of quantifying effects to coastal cutthroat trout and bull trout from monitoring, research, and restoration action, based upon available information, and further notes that much of the scientific emphasis during this conference and consultation focused upon the effects of the navigation project upon habitat indicators and habitat forming processes that may be of significance to coastal cutthroat trout and bull trout. The modeling efforts did not seek to directly quantify the long-term effects of these restoration or research activities on habitats of importance to coastal cutthroat trout and bull trout. Hence, the effects analyses associated with these monitoring, restoration, and research activities are necessarily of a different and more qualitative nature than those associated with the navigation improvements.

5.5.1 Monitoring Program

Section 2.2.6 of these Service opinions describes the elements of the comprehensive monitoring program that is part of the proposed action, and Table 2.5 enumerates objectives of each element

of the monitoring and their relation to the assumptions or predictions associated with this consultation. In Table 5.2, below, the Service describes the anticipated effects of these monitoring activities. The Service concludes that any adverse effects of implementing a monitoring program are likely to be limited, and will not cause take of coastal cutthroat trout or bull trout.

Table 5.2 Proposed Project Monitoring Activities and Effects of Monitoring Program Implementation

Monitoring Activity	Anticipated Effects of Monitoring Program to Salmonids
Maintain three hydraulic monitoring stations: One downstream of Astoria, one in Grays Bay, and one in Cathlamet Bay. Parameters measured would include salinity, water surface elevation, and water temperature.	Over-water access to maintain monitoring stations should have minimal impacts to salmonids and their habitats.
Monitor annual dredging volumes from both construction and O&M activities.	None
Conduct main channel bathymetric surveys throughout Project area.	Over-water access to conduct bathymetric surveys should have minimal impacts to salmonids and their habitats.
Repeat estuary habitat surveys being conducted by NMFS.	Over-water and aerial access to conduct habitat surveys should have minimal impacts to salmonids and their habitats.
Review the SEDQUAL database and other available data to determine if there are areas that would require additional sampling. Review existing contaminants database using NMFS guidelines or trigger values that are more protective of salmonids and trout. Provide notification during construction dredging to monitor for presence of fine-grained material – i.e., oily sheens.	Over-water access to conduct additional sediment surveys, and substrate-disturbing activities associated with additional surveys should have minimal impacts to salmonids and their habitats.
Monitor the incidence of stranding of juvenile salmon on beaches in action area. Field surveys will be made monthly at selected beaches (upper, mid, and lower river) during the April-August out-migration to measure the number of fish being stranded along beaches.	Over-water access to conduct salmonid stranding surveys should have minimal impacts to salmonids and their habitats. Handling of stranded salmonids is anticipated. Procedures for salvaging ESA-listed salmonids are provided in this Opinion's Incidental Take Statement.

5.5.2 Ecosystem Restoration Activities

The Corps proposed several ecosystem restoration activities to create or improve salmonid habitat, specifically tidal marsh/swamp and shallow water/flats habitat. Six of the seven new restoration features proposed by the Corps (Lois Island Embayment Habitat Restoration, Purple Loosestrife Control, Miller/Pillar Habitat Restoration, Tenasillahe Island Interim and Long-term Restoration, and Bachelor Slough Restoration) occur in-water and have the potential, during implementation, to affect coastal cutthroat trout and, for the above-estuary restoration projects, bull trout. The translocation of Columbian white-tailed deer to Cottonwood/Howard Island will have no effect on coastal cutthroat trout and bull trout as the action is upland in nature. Two of

the three original restoration actions identified in the FEIS (Columbia River Tidegate Retrofits and Walker-Lord and Hump-Fisher Islands Channel Connectivity Enhancements) occur in-water, so they also have the potential to affect coastal cutthroat trout and bull trout. Other original FEIS restoration actions (e.g. Shillapoo Lake) are disconnected from coastal cutthroat trout and bull trout habitats and will not have either beneficial or detrimental effects to coastal cutthroat trout and bull trout. Section 8.0 of the aquatic species BA and Chapter 4 of the Corps 1999 FEIS describe the proposed restoration activities and their effects on salmonids, including coastal cutthroat trout and bull trout. Both descriptions are incorporated here by reference.

5.5.2.1 Lois Island Embayment

Construction actions for the Lois Bay embayment restoration feature may result in temporary impacts to coastal cutthroat trout. Materials to be placed in the embayment are primarily clean, medium-grained sands that meet the guidelines for in-water placement in accordance with the DMEF. Consequently, transfer of contaminated sediments is avoided, and the turbidity plume associated with discharge into the restoration site is expected to be limited.

However, since several dredge and fill events at the temporary sump and Lois Island restoration sites will occur, there are opportunities for benthic organisms, other salmonid prey items, and coastal cutthroat trout to be affected during dredging and disposal. These actions may cause direct taking of a limited number of coastal cutthroat trout via death and injury from material disposal in shallow water Lois Island embayment habitats and deeper water temporary sump habitat, harm to coastal cutthroat trout via loss of prey items, and harassment of coastal cutthroat trout via the turbidity plume. The Service believes these effects should be limited to the sediment storage site and restoration site and will be very short in duration. In addition, placement of sediments into the Lois Island embayment will be restricted to the November 1 to February 28 in-water work window, to minimize impacts to coastal cutthroat trout. Recolonization of the restored embayment by plants will take five to ten years or more, depending on the species and their means of colonization. The tidal marsh fringing the embayment and the large expanses of tidal marsh in Cathlamet Bay represent a large source of plant propagules for the restoration site. Similarly, benthic organisms are abundant in Cathlamet Bay and represent an excellent source population for rapid recolonization of the embayment. Benthic productivity and related use by salmonids may be less for an undetermined interim period as populations reestablish and densities increase. The proposed restoration feature will be beneficial to coastal cutthroat trout in the long-term because, as tidal marsh habitats recolonize, primary (plant) and benthic productivity should approach historical levels. The proposed restoration feature would benefit coastal cutthroat trout by improving habitat complexity,

connectivity, or conveyance, feeding habitat opportunity, refugia and habitat-specific food availability.

5.5.2.2 Purple Loosestrife Control

The restoration feature for purple loosestrife control would include an integrated pest management approach using biological agents, herbicides, and mechanical control measures. These actions would typically occur in the upper elevations of tidal marsh habitat and have little likelihood of adversely affecting coastal cutthroat trout, directly or indirectly. RODEO, an EPA-registered chemical approved for over-water application, would be used in conjunction with the other control measures.

RODEO application may result in the short-term, very limited loss of some native vegetation, and will create openings in marsh habitat where non-native plants previously existed. The herbicide will be wicked and spot-sprayed on to purple loosestrife by hand, thereby limiting chemical contact with water. Wicking also lessens the potential for impacts to native vegetation. Mechanical control (pulling) would only affect a small area at any given time, typically during lower tidal stages.

By helping to eradicate purple loosestrife in the Columbia River estuary and thereby reestablish the diverse native vegetation of tidal marsh habitats, this restoration feature is likely to benefit coastal cutthroat trout. These changes should benefit habitat complexity, connectivity, or conveyance, feeding habitat opportunity, refugia, and habitat-specific food availability.

5.5.2.3 Miller/Pillar Habitat Creation

Construction actions for the Miller/Pillar habitat creation may result in temporary impacts to coastal cutthroat trout. Construction of this restoration action may result in the temporary displacement of coastal cutthroat trout from the immediate area of the discharge pipe and the pile dike construction location, and temporary loss of benthic prey items.

Materials to be used for habitat creation are primarily clean, medium-grained sands that meet the guidelines for in-water placement in accordance with the DMEF. Consequently, transfer of contaminated sediments is avoided, and the turbidity plume associated with discharge into the restoration site is expected to be limited. These actions may cause direct taking of a limited number of coastal cutthroat trout via death and injury from material disposal in shallow water habitats, harm to coastal cutthroat trout via loss of prey items, and harassment of coastal

cutthroat trout via the turbidity plume. The Service believes these effects should be limited to the restoration site and will be very short in duration.

Once construction is completed, future potential disturbance actions would be limited to maintenance of the new pile dikes, an intermittent effort over many years. Pilings and spreaders would be fitted with bird excluders to minimize or eliminate use by double-crested cormorants. A previous study has established that driving of wood piles with an impact hammer does not produce sounds that are in the hearing range of salmonids (Carlson et al. 2001).

The construction and maintenance of this restoration action, for the short-term, are likely to adversely affect coastal cutthroat trout shallow water and water column habitat, and temporarily remove some food resources, but will benefit coastal cutthroat trout by providing more productive habitats for benthic invertebrates and thus coastal cutthroat trout as well. This habitat restoration feature should result in improvements to habitat complexity, connectivity, or conveyance, feeding habitat opportunity, refugia and habitat-specific food availability.

5.5.2.4 Tenasillahe Island Tidegate and Inlet Modifications

This ecosystem restoration feature will improve both habitat connectivity and water quality of interior channels. Coastal cutthroat trout should be able to access additional acres of productive tidal marsh and swamp habitat for rearing and foraging. Construction impacts from tidegate installation and inlet modification are anticipated to be of short duration (a few days to two weeks). However, since inwater work would be required, some limited duration harassment of coastal cutthroat trout from the turbidity plume may occur. Through appropriate timing, impacts to coastal cutthroat trout in the immediate construction area can be further minimized. The Service anticipates that this action will benefit coastal cutthroat trout by opening up access to productive rearing and refuge areas that are not now accessible to coastal cutthroat trout. This action will result in improvements to water quality, habitat complexity, connectivity, or conveyance, feeding habitat opportunity, refugia and habitat-specific food availability.

5.5.2.5 Tenasillahe Island Historical Habitat Restoration

Long-term Tenasillahe Island restoration activities will only occur if Columbian white-tailed deer were delisted and the eventual long-term Tenasillahe Island restoration plan was consistent with the Julia Butler Hansen National Wildlife Refuge's purpose and goals. This future restoration action will be developed in the future, and therefore will undergo site-specific Section 7 consultation when fully designed. Conceptually, the Service believes that, should this project be undertaken, numerous ecosystem indicators would be benefitted, including tidal marsh and

swamp habitat, and all pathways associated with habitat primary productivity, food web, salmonid growth, and salmonid survival.

5.7.2.6 Bachelor Slough

This project is designed to increase river flows traveling through the slough, with associated improvements in water quality and connectivity. Coastal cutthroat trout and bull trout would be more likely to be attracted to Bachelor Slough under these changed conditions during their migrations. Cooler temperatures would be beneficial to fish in Bachelor Slough. Additionally, six acres of riparian habitat would be restored along the Bachelor Slough shoreline, plus additional riparian forest habitat would be developed on the disposal areas associated with this activity.

Dredging would occur between July 1 and September 15, to avoid periods when salmonids are most abundant. All disposal materials would be placed on existing disposal sites or upland areas. Disposal of material dredged from Bachelor Slough provides an opportunity to develop riparian forest. Riparian forest restoration would provide for detrital and insect export to the Columbia River. Permanent riparian forest habitat would provide for export of large woody debris to the Columbia River and its estuary over the long term.

Bachelor Slough sediment quality would be evaluated prior to implementation of the restoration feature to ensure dredge-released contaminants would not occur. The project would be modified if contaminants were determined to be outside established regulatory parameters for upland disposal. Timing restrictions for pipeline dredging will minimize impacts to coastal cutthroat trout and bull trout from dredging operations. Due to the project timing and the current, low quality salmonid habitat in Bachelor Slough, the Service does not believe this project will have adverse effects on coastal cutthroat trout and bull trout.

5.5.2.7 Columbia River Tidegate Retrofits

The Corps has proposed to retrofit the tidegates on five tributaries to the Columbia River, and to conduct additional tidegate retrofit activities on other tributaries in the future. The Oregon tributaries include Tide Creek, Grizzley Slough, and Fertile Valley Creek, and the two Washington tributaries include Burris Creek and Deep River. Further information on these proposals is located in Chapter 8.4 of the aquatic species BA and Chapter 4 of the Corps 1999 FEIS. That information is incorporated here by reference. Construction actions are of short duration (e.g., less than one week per structure) and soil disturbance, thus turbidity, would typically be limited in nature. If the entire tide gate and associated culvert require replacement, temporary coffer dams would be placed on each end of the culvert to preclude sediment impacts

to the stream. However, since inwater work would be required, some limited duration harassment from the turbidity plume may occur to coastal cutthroat trout and bull trout.

The tidegate retrofit restoration feature is estimated to provide or improve fish access to 38 miles of tributary streams. These tributaries contain spawning, stream rearing, and (near their confluence with either the Columbia River or a more major tributary) backwater channel and freshwater marsh habit for rearing and/or overwinter refuge from floods. Additionally, the Corps would replace additional tidegates with these same methodologies, if additional tidegate retrofit projects were identified. This action should result in short- and long-term improvements to habitat complexity, connectivity, or conveyance, feeding habitat opportunity, refugia, and habitat-specific food availability by reconnecting the Columbia River to these tributary streams.

5.5.2.8 Walker/Lord and Hump/Fisher Islands Channel Connectivity Enhancements

The purpose of this restoration action is to improve water flow and circulation through this island complex, thereby lowering embayment temperatures and creating a network of channels. This feature should increase habitat connectivity and improve foraging conditions for coastal cutthroat trout and bull trout. Construction activities are primarily upland in nature and involve construction of a channel in a historical dredged material deposition area. A brief period of in-water construction would occur when the channels at the embayment and river are opened. Given the short duration of the construction action and the fact that material to be excavated is primarily medium-grained sand, turbidity in adjacent waters should be of short duration and extent. Construction timing would typically be late summer to take advantage of lower water levels, dry soil conditions, and the general absence of fish. As a result, the potential for short-term adverse impacts to coastal cutthroat trout and bull trout would be minimized. Due to timing and location of the inwater action, the Service does not believe the restoration action will take coastal cutthroat trout and bull trout. This restoration will provide some short- and long-term improvements to habitat complexity, connectivity, or conveyance, feeding habitat opportunity, refugia, and habitat-specific food availability.

5.5.2.9 Martin Island Embayment Modification

The project objective of this wildlife mitigation action is to create tidal marsh habitat, which would increase detrital export to the Columbia River. The Proposed action may have some adverse effect on an aquatic environment, including smothering of plants, algae, invertebrates, and potentially coastal cutthroat trout and bull trout. These actions may cause limited taking of coastal cutthroat trout and bull trout via death and injury from material disposal in shallow water

habitats, harm to coastal cutthroat trout and bull trout via loss of prey items, and harassment of coastal cutthroat trout and bull trout via the turbidity plume. The Service believes these effects should be limited to the restoration site and will be very short in duration. Construction placement of dredged material and topsoil will temporarily increase turbidity, although a barrier placed at the inlet will minimize turbidity export to the adjacent side channel. However, the principal material to be placed into the embayment is primarily clean, medium-grained sand from the navigation channel, which would minimize impacts from turbidity and avoid bioaccumulation of contaminants. In the long term, the project would benefit benthic invertebrates, including those species that are used as forage resources by coastal cutthroat trout and bull trout, and improve habitat complexity, connectivity, or conveyance, feeding habitat opportunity, refugia and habitat-specific food availability. In addition, development of tidal marsh habitat would not preclude use of the embayment by coastal cutthroat trout and bull trout except during low tide periods.

5.5.3 Ecosystem Research Actions

Ecosystem research actions are measures proposed by the Corps to assist the efforts of the Corps, NMFS, the Service, and others in understanding the broader issues of the lower Columbia River, estuary, and river mouth ecosystem. These research actions address indicators of the salmonid conceptual model, and are intended to provide useful information for the conservation and recovery of coastal cutthroat trout and bull trout. The annual and cumulative results will be presented to the adaptive management team. The Service strongly supports implementation of these ecosystem research activities.

Effects to coastal cutthroat trout and bull trout and two listed terrestrial species, bald eagles and brown pelicans, are expected to occur from implementation of ecosystem research activities. Because any impact to coastal cutthroat trout and bull trout from research activities is directed and intentional, instead of incidental to the purpose of the action, the future implementation of these research activities may require the issuance of research permits authorizing direct take of listed species by either NMFS or the Service under Section 10(a)(1)(A) of the Act.

5.6 Summary of Effects of the Proposed Action on the Biological Requirements of Coastal Cutthroat Trout and Bull Trout

The analysis in 5.3.1 of these Service opinions indicate that direct effects to coastal cutthroat trout and bull trout would be limited. The Service agrees with the aquatic species BA's general assessment of potential Project indirect effects during the two year construction period of navigation improvements. Based on the conceptual model, impacts to key physical processes

have the potential for affecting habitat forming processes, i.e., the "building blocks"of salmonid habitat in the lower Columbia River, estuary, and river mouth. Those key physical processes include suspended sediment, accretion/erosion, turbidity, salinity, bathymetry, and bedload. The impacts to those key physical processes will be of a limited nature during the Project construction period, were discussed during the SEI panel process, and validated using the numerical modeling conducted by WES and OHSU/OGI. These results indicate that the indirect effects of the Project on coastal cutthroat trout and bull trout in the short-term is limited.

Based on these limited, short-term direct and indirect Project effects, the Service believes population numbers of coastal cutthroat trout and bull trout will not be appreciably reduced. The Service also believes that the Project will not appreciably reduce, other than during short-duration and limited locations of salmonid avoidance of dredging and disposal operations, the distribution of coastal cutthroat trout and bull trout. Because no coastal cutthroat trout or bull trout spawning habitat occurs in or adjacent to the Project, the Project will not cause loss of spawning habitat. Overall, the Service believes the short-term direct and indirect effects of the Project will not appreciably reduce any of the coastal cutthroat trout and bull trout population numbers, distribution within each DPS, or reproductive success.

The aquatic species BA has characterized many of these changes to key habitats and indicators over the short-term as not being significant. The Corps believe that because these predicted changes are within the natural variation of river conditions (e.g., changes to the ETM, accretion/erosion rates) or will not change river conditions at all (e.g., bedload changes, volume and rate of suspended sediment transport, water level changes to the estuary, structure, distribution, net productivity, and detritus production of marshes and swamps, the location of mobile macroinvertebrates, velocity changes in shallow water habitats and available refugia, salinity changes as they impact habitat types, bathymetry, and the impact on habitat opportunity as it relates to water depth in the estuary), that the Project will have limited effects.

During the conference and consultation process, the Service identified certain issues regarding potential long-term effects of the Project. These have centered on limited effects that may be caused by Project actions that are not detectable in the short term, but may affect salmonid habitats over the life span of the Project. This could include ecosystem effects that are not identifiable based on the Service's review of best available science and our current understanding of the ecosystem. Topics of concern identified during this reinitiation include those related to the ETM, formation and preservation of tidal marsh and swamp habitats, habitat opportunity changes in isolated geographic areas, and elimination of connectivity between habitats relied on by salmonids.

The changes to physical processes resulting from the Project will likely result in a limited, incremental, but permanent change in the physical conditions in the lower Columbia River, estuary, and river mouth. Any changes in a static system should be predictable, using modeling and other tools, over the life span of the Project. However, the ecosystem of the lower Columbia River, estuary, and river mouth is not a static system. Numerical modeling cannot account for this non-static state. As acknowledged in the aquatic species BA, these changes will result in a new dynamic equilibrium in the lower Columbia River, estuary, and river mouth ecosystem.

Not withstanding the Corps' assessments, the Service believes that the predicted changes to the lower Columbia River, estuary, and river mouth physical system should not be extrapolated over the life span of the Project without additional monitoring and verification. In the example developed as part of the OHSU/OGI modeling for the reinitiation of consultation, the potential changes to habitat opportunity in Cathlamet Bay for five one-week model simulations (Table 6-1 of the aquatic species BA) is a model simulation run over a short time duration. The aquatic species BA indicates that the proposed actions "will not have an impact on habitat opportunity as it relates to water depth." Based on the information provided in the aquatic species BA, extrapolating these results over the life span of the Project instead of limiting those results to the period modeled does not fully acknowledge potential model limitations or long-term variability in the ecosystem.

A key conclusion identified during the SEI panel process and BRT discussions was that risk and uncertainty existed regarding whether the predicted physical changes will have negative, positive, or neutral effects to listed salmonids or their habitats. That level of risk and uncertainty also surrounded the biological response of coastal cutthroat trout and bull trout to those potential physical changes over the life span of the Project. Therefore, the BRT conducted a qualitative risk and uncertainly analysis (see Table 7-1 of the aquatic species BA). That analysis documented the need for a precautionary approach to the protection of ecosystem elements (i.e., key indicators within each pathway of importance to salmonids). Therefore, the Corps proposes, and the Service agrees, that the development of a robust Monitoring Program and Adaptive Management Process is appropriate to address the Project-related risk and uncertainties raised surrounding the key coastal cutthroat trout and bull trout habitat pathways and indicators identified in these Service opinions.

5.7 Updated Analysis of Effects for Columbian White-tailed Deer and Bald Eagle

5.7.1 Columbian White-tailed Deer Effects

The aquatic species BA (8.4.1.2) provides an overview of ecosystem restoration effects to Columbian white-tailed deer. Only the Cottonwood/Howard Island Columbian white-tailed deer reintroduction and the Tenasillahe Island interim restoration activities could have an adverse influence on Columbian white-tailed deer.

Because Columbian white-tailed deer reintroduction activities, including capture from source sub-population, translocation, and subsequent release on Cottonwood/Howard islands, will potentially cause take of Columbian white-tailed deer, the Service will acquire a section 10(a)(1)(A) recovery permit for these activities. The Corps' action of supporting, via cost-share agreement, the Service's translocation activities will not have an adverse effect on the Columbian white-tailed deer. The Service believes a long-term habitat management plan should be developed between the Service and the Cottonwood/Howard islands landowners to ensure management actions provide for long-term, secure Columbian white-tailed deer habitat.

Tenasillahe Island interim restoration activities will occur adjacent to Columbian white-tailed deer habitat, and may, both during interim project construction and future tidegate operations, influence Columbian white-tailed deer. Two tidegates will be replaced and two control inlets will be constructed on Tenasillahe Island, requiring short-duration construction activity. The Service believes this construction activity, on previously-modified flood-control levees, will cause limited harassment of Columbian white-tailed deer. Tidegates will be designed to ensure that Columbian white-tailed deer habitat will not be flooded during daily tidal or high water events. The Service believes the Corps actions, through careful hydraulic engineering analysis, tidegate design, and proper instruction to Service staff regarding tidegate operation, will minimize potential longer-term impacts to Columbian white-tailed deer or their habitats at Tenasillahe Island from this interim restoration activity.

The long-term Tenasillahe Island restoration action will not occur until the Columbia population of Columbian white-tailed deer are delisted, and the Julia Butler Hansen National Wildlife Refuge has completed a thorough compatibility evaluation of long-term Tenasillahe Island restoration action's influence on the Julia Butler Hansen National Wildlife Refuge's purpose and needs. Additionally, as indicated by the aquatic species BA, no Columbian white-tailed deer incidental take coverage for the long-term restoration activities will be necessary if the population has been

delisted. Therefore, the Service does not provide any analysis of effects to Columbian white-tailed deer from this in-the-future restoration activity.

Restoration projects are anticipated to have a long-term benefit on Columbian white-tailed deer, as these projects restore habitat functions at the restoration sites, and potentially allow expansion of existing Columbian white-tailed deer into new, suitable habitats in the lower Columbia River and estuary.

5.7.2 Bald Eagle Effects

The aquatic species BA (8.4.1.3) provides an overview of ecosystem restoration effects to bald eagle. The Corps determined that effects to bald eagles would be limited to short-term harassment of bald eagles during restoration projects' construction. Restoration projects are anticipated to have a long-term benefit on bald eagles, as these projects restore habitat functions.

Three pairs of bald eagles nest near the Lois Island embayment restoration project; one pair (John Day Point/Lois Island pair) may be within ½ mile of the restoration activities, and within line-of-sight, thereby increasing the likelihood of short-term harassment. One bald eagle pair nests on Miller Sands Island near the Miller/Pillar habitat restoration project. Two bald eagle pairs nest on Tenasillahe Island near the Tenasillahe Island interim and long-term restoration actions, and two bald eagle nesting territories occur near the Bachelor Slough restoration project. Approximately 30 additional nesting pairs occur throughout the estuary and lower Columbia River, estuary, and river mouth.

Bald eagles may exhibit nesting behavior from January 1 to August 31, therefore any restoration activities within this period may influence bald eagle nesting success. The Corps has determined that the Bachelor Slough project, which is located next to the Bachelor Slough bald eagle pair, is the only ecosystem restoration action that occurs immediately adjacent to a bald eagle nest. Therefore, to avoid bald eagle harassment while nesting, the Bachelor Slough restoration action will be implemented later in the nesting period, preferably between August to October. Due to the varying proximity of restoration projects to the Bachelor Slough and Miller Sands Island pairs, and the three nesting bald eagle pairs near Lois Island embayment, bald eagle foraging behavior may be variably influenced by restoration activities. The Service generally recommends, to avoid impacts to bald eagle behavior, that human activities occur at least ½ mile line-of-sight from bald eagle activity areas. However, since these restoration projects are more than 1,500 feet from adjacent bald eagle nests, and construction is of short duration, any bald eagle harassment is limited. Restoration projects also are generally limited in size, thereby providing ample alternative foraging areas for bald eagles. The Service believes, since these bald eagles currently

experience a variety of human activities near their nesting and foraging areas, that these short-term ecosystem restoration construction activities will not create impacts that are new or unusual for bald eagles. Finally, to protect the approximately 30 nesting pairs dispersed throughout the Project area, the Corps proposes to operate the Purple Loosestrife Control project boats at least 1,500 feet from known nest sites.

The Service believes the Corps has adequately attempted to minimize and avoid adverse restoration project construction effects on bald eagle. However, there will be a limited amount of harassment of bald eagle during restoration project activities. The Service believes, in the long term, restoration projects will benefit bald eagle populations in the Columbia Recovery Zone.

6.0 CUMULATIVE EFFECTS

6.1 Introduction

Cumulative effects include the effects of future State, tribal, local or private actions that are reasonably certain to occur in the action area considered in these Service opinions. The action area of the proposed action under consideration encompasses the lower Columbia River (from Bonneville Dam downstream to the upper end of the estuary at RM 40), estuary (RM 40 to RM 3), and river mouth (RM 3 to the deep water disposal site). 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 Act.

The Project area is currently a disturbed estuarine and riverine ecosystem altered by previous dredging to establish the navigation channel, disposal of dredged material, diking and filling, sewage and industrial discharges, water withdrawal, and flow regulation, to highlight a few of the anthropogenic activities that have occurred over the last 100 years. Future Federal actions, including the ongoing operation of hydropower systems, hatcheries, fisheries, and land management activities are being (or will be) reviewed through separate Section 7 consultation processes and are not considered cumulative effects.

State, Tribal, and local government actions are likely to be in the form of legislation, administrative rules, or policy initiatives. Government and private actions may include changes in land and water use patterns, including ownership and intensity, any of which could affect listed species. Even actions that are already authorized are subject to political, legislative, and fiscal uncertainties. These realities, added to the geographic scope of the action area, which encompasses numerous government entities exercising various authorities and many private land holdings, make any analysis of cumulative effects difficult. This section identifies representative