2.5 Effects of the Action

Placeholder

2.5.1 Effects of the Action to Species

2.5.2 Effects of the Action to Critical Habitat

The PA is expected to result in numerous adverse impacts to designated critical habitat within the action area for the species addressed in this BO. The critical habitat designations for Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon list the physical or biological features (PBFs) for critical habitat for these species, and these PBFs are described in Appendix [XX]. This section provides a description in Section 2.5.2.1 of general impacts to critical habitat that are expected to occur as a result of the proposed action, and then describes specific impacts to each PBF for each ESA-listed species analyzed in this BO.

2.5.2.1 General Habitat Impacts

2.5.2.1.1 Sedimentation and Turbidity

The PA includes construction and maintenance activities that are likely to result in adverse effects to critical habitat through re-suspension and deposition of sediments already existing in river reaches within the action area or from activities along river banks that will disturb sediments and release them into the water. Specific activities include: pre-construction dredging; geotechnical borings; clearing and grubbing at construction sites; pile driving at intake sites, HOR, CCF, and at barge landings; increased vessel traffic during construction; and periodic maintenance dredging at new water diversion facilities.

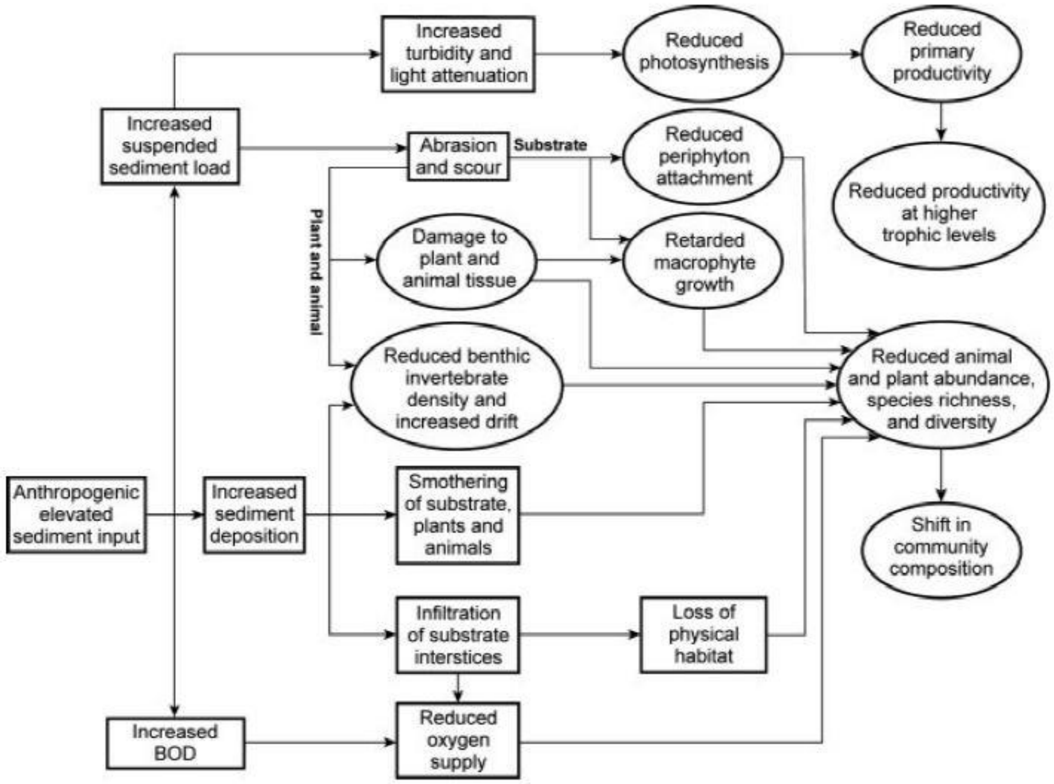

Figure XX. Negative impacts of anthropogenically enhanced sediment input to lotic aquatic systems at lower trophic levels. Rectangles and ovals respectively denote physiochemical effects and direct and long-term biological and ecological responses. *From: (Kemp et al. 2011).*

Kemp *et al.* (2011) discusses the impacts of sediment input to aquatic ecosystems and includes Figure XX, graphically depicting direct and indirect effects of sedimentary processes. A number of key components of the PBFs defined for listed fish species have the potential to be impacted by enhanced sedimentation (Wood and Armitage 1997, Kemp *et al.* 2011). This is of particular concern downstream of the north Delta intake sites during the construction phase, and downstream of sites in which maintenance dredging will occur. Sediment influx and transport can lead to geomorphologic changes in the action area that are part of natural physical processes in the Delta, creating floodplain habitat for additional recruitment of riparian vegetation (Richardson *et al.* 2007, Schoellhamer *et al.* 2012), and may also affect habitat heterogeneity in the main stem Sacramento River (Yarnell *et al.* 2006), increasing the complexity of benthic habitat. Although habitat complexity is generally viewed as beneficial for fish in lotic systems, sediment deposition also has negative impacts to habitat features that contribute to its functionality. Sediment deposition has been shown to have direct effects to aquatic macroinvertebrates in lowland river systems due to smothering (Kefford *et al.* 2010), creation of low-light conditions limiting macrophyte food sources (Sand-Jlnsen *et al.* 1989), and impact to macroinvertebrate community structure (Bo *et al.* 2007). These organisms provide a food source for listed fish species rearing and migrating through the action area. Although emergent aquatic vegetation generally benefits from sediment deposition (Richardson *et al.* 2007), submerged aquatic vegetation may be adversely impacted by sediment suspension and deposition through light attenuation (Kemp *et al.* 1983). Loss of vegetation can reduce available cover, increasing exposure of listed fish to predators (Kemp *et al.* 2011).

Increased levels of turbidity resulting from sediment influx and resuspension may impede predator avoidance behavior by reducing the perceived threat of predation. Gregory (1992) demonstrated that elevated levels of turbidity reduced the magnitude of predator avoidance responses in juvenile salmonids. From a perspective of critical habitat, the effects of sedimentation and turbidity may reduce the habitat quality of those portions of the action area that are used for rearing and migration.

2.5.2.1.2 Water Temperatures

Water temperatures in aquatic ecosystems are particularly important for early life stages of anadromous fish. Thermal tolerances and optima for early life stages of Chinook salmon and green sturgeon have been well-documented and are discussed in the *Range-wide Status of the Species and Critical Habitat* sections for each of the listed species addressed in this BO (Appendix XX). Temperature is an important component of several critical habitat PBFs among these species, as water temperatures play a large role in the suitability of habitat within the action area. For the purposes of this analysis, concerns of adverse impacts to critical habitat PBFs resulting from temperature effects are greatest at the most upstream extent of the action area (upper reaches of the Sacramento River and Lower American River between Nimbus Dam and the SR-160 Bridge). The Sacramento River contains spawning habitat for all four species and the Lower American River contains spawning habitat for CCV steelhead. There are no anticipated construction-related activities in these upper reaches included in the proposed action; therefore, localized changes in water temperature are expected to be operations-related and not due to disturbance of riparian vegetation. Specific PBFs that may be impacted by temperature and/or flow-related effects are discussed below in *Section 2.5.1.2 Operations Effects*. A discussion of the effects to species resulting from reduced in-Delta flow is included in Section 2.5.1.2.7 *Reduced In-Delta Flows.*

2.5.2.1.3 Loss of Riparian Vegetation

Riparian vegetation will be removed as a result of the PA principally through clearing and grubbing at construction sites, and also may be removed temporarily at restoration sites. Riparian vegetation plays a key role in the conservation value of rearing habitat for various salmonid and green sturgeon life stages. It provides shading to lower stream temperatures; increases the recruitment of LWM into the river, increasing habitat complexity; provides shelter from predators; and enhances the productivity of aquatic macro invertebrates (Anderson and Sedell 1979, Pusey and Arthington 2003). It has also been shown to directly influence channel morphology and may be directly correlated with improved water quality in aquatic systems (Schlosser and Karr 1981, Dosskey *et al.* 2010). It has been suggested by Dosskey *et al.* (2010) that presence and abundance of riparian vegetation can be directly correlated with water quality in riverine systems through biogeochemical cycling, soil and channel chemistry, water movement and erosion.

Riparian vegetation also plays a key role in the functionality of estuarine habitat. The majority of riparian habitat that is to be disturbed in the course of this project will be upstream of the Delta (north Delta diversions and compensatory mitigation sites), but some disturbance is expected to occur in the course of constructing barge landings in the Delta. Riparian vegetation provides enhanced rearing habitat in inundated floodplains for estuarine fish species (Sommer *et al.* 2001a, Sommer *et al.* 2001b). In some estuarine habitat types such as saltmarshes (Williams and Williams 1998), and supralittoral zones (Romanuk and Levings 2003), it contributes to proliferation of aquatic macro invertebrates. Riparian vegetation also influences geomorphic features in tidally-influenced estuarine areas, facilitating natural erosional and depositional processes (Tabacchi *et al.* 1998, Temmerman *et al.* 2007).

Compensatory habitat mitigation will be implemented at a NMFS-approved conservation bank in order to offset the negative impacts to riparian habitat associated with the PA. Details on compensatory habitat mitigation are discussed in Section 2.5.1.1 *Construction Effects*.

2.5.2.1.4 Reduction in Habitat Complexity

Note: This section incomplete. Will be completed after Delta fry analysis is complete. Include paragraph here describing general impacts of loss of habitat complexity for salmonids (e.g. loss of deep pools for green sturgeon)

2.5.2.1.5 Prey Availability

One of the most important habitat attributes of the riverbed to listed anadromous fish species in the action area is the production of food items for rearing and migrating juveniles. Salmonid and sturgeon prey items will be impacted primarily by dredging activities and barge operations which adversely impact juvenile rearing and migratory habitat. Oligochaetes and chironomids (dipterans) are the dominant juvenile Chinook salmon, steelhead, and sDPS green sturgeon food items produced in the silty and sandy substrates in this area. Radtke (1966) inspected the stomach contents of juvenile green sturgeon (range: 200-580 mm) in the Delta and found food items to include mysid shrimp (*Neomysis awatschensis)*, amphipods (*Corophium sp.)*, and other unidentified shrimp. Populations of these organisms would be entrained by the hydraulic suction dredge, particularly small demersal fish and benthic invertebrates. Reine and Clark (1998) estimated that the mean entrainment rate of a typical benthic invertebrate, represented by the grass shrimp, when the cutterhead was positioned at or near the bottom was 0.69 shrimp/cubic yard but rose sharply to 3.4 shrimp/cubic yard when the cutterhead was raised above the substrate to clean the pipeline and cutterhead assembly. Likewise, benthic infauna, such as clams, would be entrained by the suction dredge in rates equivalent to their density on the channel bottom, as they have no ability to escape.

2.5.2.1.6 Water Quality

Degradation of water quality in the action area may have adverse impacts to certain PBFs for designated critical habitat through the following mechanisms: re-suspension of contaminated sediment; possible reduction of dissolved oxygen through re-suspension of contaminants; elevated water temperatures; and decreased flow. These mechanisms are expected to result in negative impacts to critical habitat for the species addressed in this BO with the exception of reduced DO, which is not expected to occur at a magnitude which would adversely impact habitat. A detailed discussion of water quality impacts to listed fish species can be found in Section 2.5.1.1.3 *Contaminant Exposure*. The majority of contaminant-related impacts to habitat are expected to occur due to the resuspension of contaminated sediment during dredging activities. The potential for contaminant incursion due to spills from construction or barge operations exists. However, there will be BMPs and avoidance and minimization measures in place that are expected to minimize the potential for introduction of contaminants to surface waters and guide rapid and effective response in the case of inadvertent spills of hazardous materials*: Worker Awareness Training; Construction Best Management Practices and Monitoring; Stormwater Pollution Prevention Plan; Erosion and Sediment Control Plan; Hazardous Materials Management Plan; Spill Prevention, Containment, and Countermeasure Plan; Disposal of Spoils, Reusable Tunnel Material, and Dredged Material; and Barge Operations Plan*.

In addition to the impacts to species as described above, water quality degradation due to contamination has the potential to reduce the abundance of aquatic macroinvertebrates, reducing the abundance of food resources at lower trophic levels for listed fish species (Phipps et al. 1995, Fleeger et al. 2003). Prey availability is a common component of critical habitat PBFs as described below in Sections 2.5.2.2 – 2.5.2.5.

2.5.2.2 Effects to Critical Habitat for ESA-Listed Salmonids Addressed in this BO

This section addresses impacts to designated critical habitat for the following species: Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and California Central Valley steelhead. Habitat impacts are structured by habitat types that occur within the action area. Specific PBFs that correspond to ESA-listed critical habitat for each species are identified within the associated habitat type. The detailed analysis of stressors to the species is contained in Section 2.4 *Effects of the Action on the Species* and will be referred to throughout this section as those analyses are relevant to the impacts to critical habitat. In many cases, the species effects analysis is relied on as underlying support for the critical habitat analysis.

Critical habitat for both CV spring-run Chinook salmon and CCV steelhead was designated concurrently, therefore, they share the same PBFs. The PBF's for winter-run Chinook salmon are generally related to the same habitat types as the other listed salmonids, but are described with more specificity in the designation. In this section, discussion of effects to the components of each PBF are delineated by species where necessary. Differences in habitat impacts are generally due to the spatial and temporal distribution of each species within the action area. In some cases, effects to one or more component of a PBF apply in the same way to each species' habitat.

2.5.2.2.1 Habitat for Spawning Adults, Incubation of Eggs, and Rearing for Fry

<u>Sacramento River winter-run Chinook salmon PBFs:</u>

- *Availability of clean gravel for spawning substrate*
- *Adequate river flows for successful spawning, incubation of eggs, fry development and emergence, and downstream transport of juveniles*
- *Water temperatures between 42.5–57.5°F (5.8–14.1°C) for successful spawning, egg incubation, and fry development*
- *Habitat areas and adequate prey that are not contaminated*

<u>CV spring-run Chinook and CCV steelhead PBFs:</u>

- *Freshwater Spawning Sites*

Spawning habitat occurs for all three species in the upper reaches of the Sacramento River (primarily from RBDD to Keswick Dam). Spawning habitat also occurs for CCV steelhead in the Lower American River. *Section 2.5.1.2 Operations Effects* discusses impacts to flow, temperature, and frequency of redd dewatering as a result of the PA. Note: More details about impacts to critical habitat from temperature and flow changes will be added later. In summary, there are frequent rates of temperature exceedance, flow changes, and changes in redd dewatering frequency that are projected to occur as a result of the PA. These differences are based on model projections provided in the BA and are projected to occur in certain months and certain water year types (see Section 2.5.1.2 *Operations Effects*).

The PA does not include any construction-related in-water activity that would disturb, contaminate, remove, or otherwise degrade spawning gravel within the known primary spawning range for Chinook salmon and steelhead in the Sacramento River. Due to a lack of any construction activity within the spawning areas, there is not expected to be any contaminant incursion to any component of this area. However, these PBFs occurring in the Sacramento River are expected to be degraded as a result of operations-related effects resulting from the PA.

Minimal degradation is anticipated for these PBFs within the Lower American River. Flow, temperature, and dewatering frequency changes discussed in *Section 2.5.1.2 Operations Effects*, indicate minimal differences between the PA and NAA based on modeled projections included in the BA. The PA also does not include any construction activity that would disturb spawning gravel or contaminate any spawning habitat components within the Lower American River.

2.5.2.2.2 Freshwater Rearing Habitat for Juveniles

<u>Sacramento River winter-run Chinook PBFs:</u>

- *Habitat areas and adequate prey that are not contaminated*
- *Riparian habitat that provides for successful juvenile development and survival*

<u>CV spring-run Chinook and CCV steelhead PBFs:</u>

- *Freshwater Rearing Sites*

Freshwater rearing habitat occurs for all three species in the mainstem Sacramento River downstream to the Delta. As discussed in Section 2.5.1.1.4.1 *Clearing, Grubbing, and Maintenance*, removal of riparian vegetation will occur in the action area at construction sites for the NDD. These impacts total approximately 20.1 acres of tidal perennial habitat and 1.02 linear miles of channel margin habitat that encompass the in-water work areas and permanent footprints of intake structures. The footprint of each intake structure, including cofferdams, transition wall structures, and bank protection (riprap), would result in the permanent loss of approximately 6.6 acres of tidal perennial habitat and 1.02 linear miles of shoreline and associated riparian vegetation. At each intake location, these structures would encompass 1,600-2,000 linear feet of shoreline and 35 feet (5-7%) of the total channel width. General effects to anadromous fish habitat resulting from disturbance to riparian vegetation include loss of shading, recruitment of LWM into the river, habitat complexity, and shelter from predators. It also may result in a loss of aquatic macro invertebrate production and may have adverse effects to water quality. These effects are discussed in greater detail in Section 2.5.2.1.3 *Loss of Riparian Vegetation*. These impacts are expected to occur within the footprint of the NDD as a result of the PA. Given the relative scale of permanent loss of riparian vegetation compared to the total abundance of vegetation in the immediate area, and as discussed in Section 2.5.1.1.5.5 *Clearing and Grubbing at Construction Sites*, coupled with the habitat mitigation/compensation proposed as part of the PA, it is unlikely that the resultant reduction of aquatic macroinvertebrate productivity or loss of shading will lead to significant degradation of these PBFs.

Installation of interim structures and reduction of habitat complexity at the NDD sites are expected to result in increased predation, as artificial structures in the water can create predator habitat (see section 2.5.1.1.6.3). Freshwater rearing PBFs will also be degraded in the vicinity of the NDD resulting from barge operations. As described in 2.5.1.1.7.3 *Barge Propeller Injury and Entrainment*, rearing juvenile salmonids will be at risk of propeller entrainment as barge operations are expected to occur year-round during the period of barge operations. In-water work involving acoustic impacts and additional construction-related disturbances are expected to occur during months in which juvenile CCV steelhead are rearing near the NDD sites. Likewise, sedimentation events affecting CCV steelhead are likely to occur during in-water work windows as a result of dredging, geotechnical boring, and pile driving. Sedimentation resulting from barge operations is expected year-round during the period of barge operations and will affect freshwater rearing habitat PBFs. . As discussed in Section 2.5.1.2.5 *Screen Impingement and Entrainment North Delta Intakes*, risk of impingement exists at the NDD screens, reducing the conservation value of freshwater rearing habitat in those locations. Although the screens will be designed to minimize approach velocities such that they do not exceed salmonid swimming capabilities, the area will be tidally influenced and sweeping velocities may decrease to a point at which risk of impingement may occur, degrading the functionality of rearing habitat. Additional degradation to Freshwater Rearing PBFs in the Sacramento River is anticipated as a result of physical and acoustic (steelhead only –due to timing/presence of the juvenile life stage) disturbance; increased predation risk; sedimentation; risk of impingement; and loss of habitat complexity.

As discussed in Section 2.5.1.1.3 *Contaminant Exposure*, due to the implementation of avoidance and minimization measures and BMPs, it is unlikely that construction-related spills or contaminants will impact freshwater rearing habitat in the action area. However, some contaminant exposure is anticipated in the vicinity of the NDD sites as a result of re-suspension of contaminated sediment due to barge operation, which will result in some degradation of these PBFs.

All three species are known to exhibit juvenile rearing (non-natal for winter-run and spring-run) in the Lower American River and CCV steelhead also rear in the San Joaquin River. Because there will not be any construction activity in these areas, there are no anticipated construction-related impacts to these PBFs in the Lower American River as a result of the PA. Construction work at the HOB on the San Joaquin River will occur during an in-water work timing that is designed to protect the migrating juvenile steelhead, so minimal impacts to the *Freshwater Rearing* PBF utilized by juvenile steelhead are anticipated.

2.5.2.2.3 Freshwater Migratory Corridors for Outmigrating Juveniles and Spawning Adults

Sacramento River winter-run Chinook PBFs:

- *Adequate river flows for successful spawning, incubation of eggs, fry development and emergence, and downstream transport of juveniles*
- *Access from the Pacific Ocean to appropriate spawning areas in the upper Sacramento River*
- *Access downstream so that juveniles can migrate from the spawning grounds to San Francisco Bay and the Pacific Ocean*

CV spring-run Chinook and CCV steelhead PBFs:

- *Freshwater Migration Corridors*

For the purposes of this analysis, freshwater migration corridors for the salmonids addressed in this BO refers to those migratory corridors linking estuarine habitat in the Delta and spawning habitat in upstream spawning reaches. Critical habitat designated within the action area that contains freshwater migratory habitat for all three salmonid species is confined to the mainstem Sacramento River. Freshwater migratory habitat for CCV steelhead also includes the Lower American River and the portion of the lower San Joaquin River located within the Delta. Effects to critical habitat within the Delta are discussed in the context of estuarine PBFs in Section 2.5.2.2.4.

The impacts to juvenile rearing habitat in the vicinity of the NDD as described in Section 2.5.2.2.2 are likely to result in some degradation to migratory PBFs for juvenile life stages in that area for all three salmonid species. Increased predation risk, risk of impingement, and loss of habitat complexity are all stressors that may reduce juvenile survival during outmigration, thus degrading PBFs related to migratory behavior. Additionally, physical and acoustic disturbance, and sedimentation may degrade migratory habitat utilized by CCV steelhead in this area.

Spawning adults migrating through the mainstem Sacramento River are likely to encounter physical disturbance from barge operations year-round during the period of barge operations which may impede upstream migration, degrading these PBFs for all three species. Adult CCV steelhead may also encounter construction-related acoustic and physical disturbances during in-water work windows, further degrading the migratory corridor PBF for this species.

Freshwater migratory corridors also occur for CCV steelhead within the action area in the Lower American River and San Joaquin River. Degradation to the migratory corridor PBF for this species as a result of the PA are not expected to occur in the Lower American River. In the portion of the San Joaquin within the Delta, migratory habitat for juveniles will likely not be impacted due to timing of in-water work windows. Migratory habitat for adults in this area however, will likely be impacted as they may migrate upstream in the San Joaquin during the proposed in-water work window.

2.5.2.2.4 Estuarine Habitat for Rearing and Migration

Sacramento River winter-run Chinook PBFs:

- *Habitat areas and adequate prey that are not contaminated*
- *Riparian habitat that provides for successful juvenile development and survival*
- *Access from the Pacific Ocean to appropriate spawning areas in the upper Sacramento River*
- *Access downstream so that juveniles can migrate from the spawning grounds to San Francisco Bay and the Pacific Ocean*

CV spring-run Chinook and CCV steelhead PBFs:

- *Estuarine areas*

For the purposes of this analysis, estuarine habitat within the action area is considered to be confined to the legal Delta, as well as waterways between the legal Delta and the Golden Gate Bridge. Although the NDD sites are within the legal Delta boundary, effects to critical habitat (i.e. rearing and migration) pertaining to those components of the PA are discussed in Sections 2.5.2.2.2 and 2.5.2.2.3. There are some differences in the exact delineation of critical habitat for the listed salmonids species that are important to note here as it relates to the impacts to estuarine critical habitat within the Delta. Within the legal Delta, critical habitat occurs for spring-run Chinook in northern portions of the Delta including various tidal sloughs upstream to Knight's Landing on the Sacramento River. The downstream boundary of designated critical habitat terminates at Sherman Island. For winter-run, designated critical habitat includes waterways downstream of Sherman Island to the Golden Gate Bridge. Upstream of Sherman Island, only the mainstem Sacramento River is designated critical habitat within the legal Delta upstream to Knight's Landing. For CCV steelhead, the entire legal Delta is designated critical habitat as well as waterways downstream to the Golden Gate Bridge, excluding San Francisco Bay.

Minimal loss of riparian habitat is anticipated to occur at barge landing sites located within the Delta. The footprint of construction at these sites is not yet determined; however, associated removal of vegetation is expected to result in relatively minor impacts to these PBFs. Estuarine PBFs of all three species may be degraded due to physical disturbance and risk of propeller entrainment year-round as barge operations are carried out in the Delta. In addition to physical disturbance by barges, juvenile CCV steelhead may also encounter physical and acoustic disturbance as pile driving and other construction activities are carried out at barge landing sites and at the HOR gate construction site. These disturbances will cause some degradation of the estuarine PBF for CCV steelhead as rearing and migratory behavior for juveniles may be impacted.

Construction and maintenance activities are likely to cause sedimentation events which may directly impact CCV steelhead rearing and/or migrating near barge landing and HOR construction sites in the Delta. Risk of exposure to suspended sediment, which may cause physical injury or may result in contaminant exposure. Additionally, impacts to benthic substrate may also impact availability of prey. These added stressors will likely cause some degradation to estuarine PBFs.

Changes to in-Delta flow are projected to result in routing changes to juveniles of each salmonid species. Entry into the interior Delta is expected to increase under the PA in the months of October, November, June, and sometimes March. Travel time through the Delta is expected to increase for juveniles outmigrating from the Sacramento River past the NDD; however, travel times for CCV steelhead outmigrating from the San Joaquin are expected to decrease. Increased travel times in the Delta will likely increase risk of predation during outmigration, degrading these PBFs.

Estuarine PBFs for later life stages will also be degraded due to the presence of barge traffic in the Delta. Migratory components of estuarine habitat may be impacted due to physical disturbances along migratory routes through the Delta that connect marine habitat in the Pacific Ocean to upstream spawning grounds throughout the Central Valley.

2.5.2.3 Effects to sDPS Green Sturgeon Critical Habitat

sDPS green sturgeon critical habitat includes PBFs that describe features of habitat types for multiple life stages. This section is structured similarly to Section 2.5.2.2 *Effects to Critical Habitat for ESA-Listed Salmonids Addressed in this BO*, by habitat types associated with life stages that are present within the action area. Specific PBFs that are present in the action area are identified within each habitat type and described in the context of each life stage.

2.5.2.3.1 Habitat for Spawning Adults, Incubation of Eggs, and Rearing for Larvae

sDPS green sturgeon PBFs:

- *Substrate Type or Size*
- *Water Flow*
- *Water Quality*

Spawning habitat occurs for sDPS green sturgeon in the upper reaches of the Sacramento River and likely concentrated between the GCID upstream to the RBDD (refer to Section 2.2 *Rangewide Status of the Species and Critical Habitat*. *Section 2.5.1.2 Operations Effects* discusses impacts to flow, temperature as a result of the PA. In summary, there are relatively minor differences in temperature and flow that are projected to occur as a result of the PA. These minor differences are based on model projections provided in the BA and are only projected to occur in certain months and certain water year types.

The PA does not include any in-water activity that would disturb, contaminate, remove, or otherwise degrade spawning gravel within the known primary spawning range for green sturgeon in the Sacramento River. Likewise, due to a lack of any construction activity, contaminant incursion to any component of this area is not expected. Therefore, these PBFs occurring in the Sacramento River are expected to be minimally degraded as a result of the PA.

2.5.2.3.2 Freshwater Rearing Habitat for Juveniles and Subadults

sDPS green sturgeon PBFs:

- *Food Resources*
- *Water Flow*
- *Water Quality*
- *Sediment Quality*

- *Depth*

The anticipated impacts to sDPS green sturgeon freshwater rearing habitat are similar to those discussed for salmonids in Section 2.5.2.2.2. Due to the complex life history and varied timing of presence throughout the action area for juveniles and subadults, construction activities are anticipated to affect critical habitat utilized by these life stages year-round during the construction period. Differences in impacts from those anticipated for salmonids are that the removal of riparian vegetation will likely impact this species less because at the juvenile and subadult life stages, they are primarily benthically oriented. Likewise, the entrainment and impingement threat to salmonids at the NDD screens is most likely not an issue for sturgeon. If debris loading becomes an issue at the screens, then juvenile sturgeon could become impinged but this is expected to be rare situation when the Sacramento River is at high flood stage. Because green sturgeon are benthically-oriented fish and the juveniles are larger than juvenile salmonids, any activities in the PA that may increase predation of salmonids are not a concern for green sturgeon.

Disturbance to benthic substrate resulting from construction activities is likely to reduce benthic macroinvertebrate prey abundance for green sturgeon at the NDD sites, resulting in some degradation to these PBFs at those locations. Rearing individuals may be exposed to contaminated sediment that is re-suspended as a result of barge operations or construction activity, and sedimentation events due to construction activity at the NDD sites (see Sections 2.5.1.1.3 *Contaminant Exposure* and 2.5.1.1.2 *Sediment Concentration and Turbidity Stress*). . Sturgeon are known to rear in deep pools, and the displacement of sediment during dredging activities may impact this habitat feature within NDD dredging footprints. The addition of these stressors is likely to degrade the conservation value of these PBFs in the vicinity of the NDD construction sites.

Freshwater rearing areas for juveniles and subadults also occur within the lowest reaches of the American River (downstream of the SR-160 bridge), and in the lower reaches of the San Joaquin River, although little is known about potential rearing behavior for sDPS green sturgeon in the San Joaquin River. Impacts as a result of the PA are not anticipated to impact PBFs associated with freshwater rearing habitat in these locations.

2.5.2.3.3 Freshwater Migratory Corridors for Outmigrating Juveniles and Spawning Adults

<u>sDPS green sturgeon PBFs:</u>

- *Migratory Corridor*
- *Depth*
- *Sediment Quality*

For the purposes of this analysis, freshwater migration corridors for sDPS green sturgeon addressed in this BO refers to those migratory corridors linking estuarine habitat in the Delta and spawning habitat in upstream spawning reaches in the Sacramento and Feather (not in the action area) rivers. Critical habitat designated within the action area that contains freshwater migratory habitat for this species is confined to the mainstem Sacramento River. Since sDPS green sturgeon are only known to spawn in the Sacramento River watershed, Lower American and San

Joaquin Rivers are not considered to be migratory corridors and are therefore not included in this analysis.

The impacts to freshwater rearing habitat in the vicinity of the NDD as described in Section 2.5.2.3.2 are likely to result in some degradation to migratory PBFs for juvenile, subadult, and adult life stages in that area. Degradation of benthic habitat, exposure to sedimentation events, and risk of physical and acoustic disturbance are stressors that may reduce survival or impact behavior during migration, thus degrading PBFs related to migration. Migratory behavior may be impacted year-round as temporal patterns of migratory behavior for various lifestages of sDPS green sturgeon are highly variable.

2.5.2.3.4 Estuarine Habitat for Rearing and Migration

sDPS green sturgeon PBFs:

- *Migratory Corridor*
- *Depth*
- *Sediment Quality*
- *Water Quality*

For the purposes of this analysis, estuarine habitat within the action area is considered to be the legal Delta, and waterways between the legal Delta and the Golden Gate Bridge. Although the NDD sites are within the legal Delta boundary, effects to critical habitat pertaining to those components of the PA are discussed in Sections 2.5.2.3.2 and 2.5.2.3.3. For sDPS green sturgeon, the entire legal Delta is designated critical habitat as well as all waterways downstream to the Golden Gate Bridge.

The Estuarine Habitat PBF for Juvenile, subadult, and adult life stages is expected to be degraded due tophysical disturbance and a risk of propeller entrainment year-round as barge operations are carried out in the Delta. Additional degradation to critical habitat is expected to result from physical and acoustic disturbance as pile driving and other construction activities are carried out at barge landing sites and at the HOR gate construction site. Deep pools, which are known to be preferred by subadults and adults, may be impacted by maintenance dredging operations or dredging operations related to construction activities at barge landings or the HOR site. Benthic food resources for these life stages will likely be reduced in Delta areas that experience heavy dredging activity as a result of long-term maintenance dredging. These disturbances will cause some degradation of these PBFs as rearing and migratory behavior for these life stages may be impacted.

Construction and maintenance activities are likely to cause sedimentation events which may directly impact estuarine habitat near barge landing and HOR construction sites in the Delta. Degradation to the Estuarine Habitat PBF may result from risk of exposure to suspended sediment, which may cause physical injury or may result in contaminant exposure.

2.5.2.4 Summary of Effects to Critical Habitat for Each Species

Critical habitat impacts are summarized in this section for each species. Conclusions for the overall impacts to designated critical habitat for each species are scaled from 'minimal' to 'moderate' to 'high'.

2.5.2.4.1 Sacramento River Winter-Run Chinook

Negative effects to winter-run critical habitat will likely be concentrated to spawning reaches and Delta migratory corridors, Changes to flow, temperature, and redd dewatering frequency in the upper reaches of the Sacramento River are projected to occur in egg incubation months during certain water year types. These impacts are especially significant because there is currently only one population of winter-run Chinook in the Central Valley and the action area encompasses all of their spawning habitat. Some degradation to rearing and migratory habitat in both the mainstem Sacramento River and Delta are anticipated to occur as a result of barge traffic in the area, which will occur year-round during the period of barge operations and is expected to result in physical disturbance, exposure to re-suspended contaminated sediment, and risk of propeller entrainment. Loss of habitat complexity at the NDD sites will also likely degrade migratory PBFs for juveniles, as this will increase the risk of predation within the NDD structural footprint. The in-Delta flow analysis concludes that there will be adverse effects to this species in the Delta including impacts to travel time, routing, and through-Delta survival. This conclusion indicates that there will be some degradation to the estuarine PBF for this species. Under the PA, greater frequency of routing into the interior Delta is anticipated due to increased through-Delta travel timing and altered routing which is expected to degrade migratory PBF for the juvenile life stage. Compensatory habitat mitigation will be implemented to offset negative impacts associated with the PA to PBFs which include freshwater and estuarine riparian habitat for rearing and migration, and in-stream habitat complexity.

Taking into account the project impacts to each PBF as well as proposed compensatory habitat mitigation, Sacramento River winter-run Chinook salmon critical habitat will be highly impacted by the PA.

2.5.2.4.2 CV Spring-Run Chinook

Negative effects to spring-run critical habitat are expected to be concentrated at the NDD intake sites due to construction activity and barge traffic at that location. Upstream flow and temperature effects in the upper Sacramento River are expected to be lesser in magnitude than for winter-run due to egg incubation timing. The spawning period for spring-run Chinook salmon occurs from mid-August through early October (Moyle 2002), whereas the spawning period for winter-run Chinook salmon occurs from late April through mid-August (NMFS 2014) when elevated water temperatures are of higher concern in the Sacramento River. Also, given that spring-run spawning habitat extends into several tributaries of the Sacramento River watershed, the amount of spawning habitat occurring in the mainstem Sacramento River is a small percentage of the total area of spawning habitat utilized by this species. Therefore, a small proportion of the critical habitat for the ESU will experience minor changes in flow and temperature resulting from the PA, and these changes are not expected to result in significant overall degradation to spring-run spawning habitat PBFs. As discussed for winter-run critical habitat at the NDD sites, barge operations are anticipated year-round during the period of barge operations and this is expected to result in physical disturbance, exposure to re-suspended contaminated sediment, and risk of propeller entrainment. Similar impacts are anticipated to occur within juvenile CV spring-run rearing and migratory habitat at barge landing sites in the Delta. As described in the above section for winter-run critical habitat (2.5.2.4.1), loss of habitat complexity at the NDD sites will likely degrade migratory PBFs for juveniles, as this will increase the risk of predation within the NDD structural footprint. Conclusions made in the in-Delta flow analysis for species effects suggest that there will be some degradation to the estuarine PBF for this species due to increased migration timing and altered routing. Under the PA, greater frequency of routing into the interior Delta is anticipated, as well as increased Delta travel times, resulting in degradation to migratory and estuarine PBFs. In-Delta flow effects to CV spring-run critical habitat are expected to be lesser in magnitude than the anticipated effects to winter-run critical habitat (see Section 2.5.1.2.7 *Reduced In-Delta Flows*). Compensatory habitat mitigation will be implemented to offset negative impacts associated with the PA to PBFs, including freshwater and estuarine riparian habitat for rearing and migration, and in-stream habitat complexity.

Taking into account the project impacts to each PBF as well as proposed compensatory habitat mitigation, Central Valley spring-run Chinook salmon critical habitat will be moderately impacted by the PA.

2.5.2.4.3 CCV Steelhead

Flow, temperature and dewatering effects to steelhead critical habitat in the upper Sacramento River are expected to be lesser in magnitude than for winter-run due to egg incubation timing and relatively small percentage of total spawning habitat utilized by CCV steelhead that occurs in the upper Sacramento River. The spawning period for CCV steelhead occurs from December through April (Hallock et al. 1961, McEwan 2001), whereas the spawning period for winter-run Chinook salmon occurs from late April through mid-August (NMFS 2014) when elevated water temperatures are of higher concern in the Sacramento River Construction-related effects to critical habitat for this species will be more extensive than for winter-run or spring-run Chinook as juvenile CCV steelhead are expected to be present in the action area during scheduled construction in-water work windows. Juveniles are typically present from November through June (peaking in February and March), and adults may begin their upstream migration through the action area as early as June, extending through March. Physical disturbances to rearing and migration PBFs resulting from construction activities include: barge operations and other construction activity at the NDD sites; barge landing sites; and the HOR construction site. Also, sedimentation events and contaminants sourced from re-suspended sediment as a result of construction-related disturbance to benthic substrates will impact rearing and migration PBFs. Overall, rearing and migration habitat for CCV steelhead is expected to be degraded in a manner similar to winter-run and spring-run Chinook; however, additional degradation of critical habitat conservation value is anticipated as some juveniles will be using critical habitat at the above named construction sites during scheduled in-water work windows. Loss of habitat complexity within the NDD footprint due to permanent disturbance of riparian habitat are expected to degrade the migratory PBF for CCV steelhead. The in-Delta flow analysis concluded that some routing into the interior Delta may occur for outmigrating juveniles, suggesting that there will be degradation to the migratory PBF.

Taking into account the project impacts to each PBF, as well as proposed compensatory habitat mitigation, California Central Valley steelhead critical habitat will be moderately impacted by the PA. Note: DWR's habitat mitigation proposal is not final as of 12/23/2016. We will describe the benefits and temporary impacts in more detail when we have them.

2.5.2.4.4 sDPS Green Sturgeon

Negative impacts to sDPS green sturgeon critical habit will primarily occur from the following: disturbances to benthic substrate due to barge operation and other construction activities, acoustic disturbances resulting from pile-driving activity, and physical disturbance and risk of propeller entrainment due to barge operations. Juvenile, subadult, and adult green sturgeon rely heavily on benthic food resources. Localized disturbance to benthic macroinvertebrate communities is anticipated at NDD sites, barge landing sites, and at the HOR construction site. Like CCV steelhead, various life stages of sDPS green sturgeon are expected to be present during in-water construction work windows, so some degradation to PBFs pertaining to rearing and migration in the Delta is anticipated due to construction-related impacts. In-Delta flow reductions are not expected to impact estuarine PBFs for green sturgeon as they are not anticipated to impact growth or survival in the Delta. The conservation value of designated critical habitat in the Delta is not expected to be diminished as a result of in-Delta flow reductions.

Taking into account the project impacts to each PBF, sDPS green sturgeon critical habitat will be moderately impacted by the PA.

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