the water level, which reduces the inundation index of wetland and riparian benches that may serve as rearing habitats (Section 5.4.1.3.2.2 of the BA Habitat Suitability). With few exceptions, the inundation index for wetland and riparian benches is lower under the PA particularly in mainstem Sacramento River downstream of NDD, Sutter and Steamboat Sloughs, and the Sacramento River to Rio Vista reach (Section 5.4.1.3.2.2 of the BA Habitat Suitability). Ongoing diversions at the CVP and SWP export facilities in the south Delta are expected to cause changes in hydrodynamic conditions, but the extent to which export-related changes in hydrodynamic conditions may degrade PBFs associated with estuarine habitat for rearing and migration of all life stages of green sturgeon.

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 upstream reaches and Delta rearing and migratory corridors. Projected decreases in both spawning and fry and juvenile rearing WUA will cause a medium-level magnitude of degradation to spawning and rearing habitat PBFs. Overall, the monthly temperature modeling results, exceedance plots and biological tools all indicate that thermal impacts on the PBFs of winter-run Chinook salmon critical habitat that relate to spawning will largely be the same with implementation of either the NAA or PA operations. Adverse thermal effects on these PBFs from changes to upstream operations as a result of the PA are not expected. However, for purposes of the analysis in Section 2.7 Integration and Synthesis, the combined effect of PA implementation when added to the environmental baseline and modeled climate change impacts is expected to result in substantial degradation to spawning PBFs in critically dry years. The revised PA (Appendix A2) however, includes a recommitment to expanding the available habitat for spawning adults, incubation of eggs, and rearing for fry, specifically, in Battle Creek and above Shasta Dam, into the McCloud River. In addition, the revised PA includes 80 acres of expanded rearing habitat through restoration in the upper Sacramento River between Keswick Dam and RBDD and 1,800 acres of tidal rearing habitat restoration in the Delta. Although these additional habitat restoration activities will have short-term impacts to habitat from ground and in-water disturbance the restoration is expected to begin improving these PBFs before proposed action operations commence and improve this PBF for all listed salmonids in the long-term.

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 and impingement within the NDD structural footprint. The PA describes the incorporation of refugia along the NDD screens that may provide additional minimization to screen impingement and associated predation risk. Phased testing and operation of the three NDD intakes will ensure that the screens are functioning to NMFS screening criteria.

The in-Delta flow analysis concludes that there will be adverse effects to Sacramento River winter-run Chinook critical habitat in the Delta including impacts to rearing and migratory habitats in this area. Also, availability of rearing habitats in the North Delta is likely to be reduced under the PA because reduced flows downstream of NDD lower the water level, which reduces the inundation index of wetland and riparian benches that serve as rearing habitats. These conclusions indicate that there will be degradation to the estuarine habitat PBFs for this species. Under the PA, greater frequency of routing into the interior Delta is anticipated due to reduced in-Delta flows, which is expected to degrade migratory PBFs for the juvenile life stage. However, the revised PA unlimited pulse protections will reduce the impact to juvenile migration routing and travel time to some degree.

Taking into account the project impacts to each PBF, as well as the revised PA habitat improvements, the Sacramento River winter-run Chinook salmon critical habitat will likely be impacted to a moderate level by the PA. Commitments to adaptive management (as described in Appendix A2) will ensure impacts are minimized.

2.5.2.4.2 CV Spring-Run Chinook Salmon

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. Projected decreases in both spawning and fry and juvenile rearing WUA will cause a low-level magnitude of degradation to spawning and rearing habitat PBFs. Overall, the monthly temperature modeling results, exceedance plots and biological tools all indicate that thermal impacts on the PBFs of spring-run Chinook salmon critical habitat that relate to spawning will largely be the same with implementation of either the NAA or PA operations. Adverse thermal effects on these PBFs from changes to upstream operations as a result of the PA are not expected. However, for purposes of the analysis in the Integration and Synthesis section, the combined effect of PA implementation when added to the environmental baseline and modeled climate change impacts is expected to result in substantial degradation to spawning PBFs in critically dry years. The revised PA (Appendix A2), however, includes a recommitment to expanding the available habitat for spawning adults, incubation of eggs, and rearing for fry, specifically, in Battle Creek and above Shasta Dam, into the McCloud River. In addition, the revised PA includes 80 acres of expanded rearing habitat through restoration in the upper Sacramento River between Keswick Dam and RBDD and 1,800 acres of tidal rearing habitat restoration in the Delta. Although the target species for these efforts is winter-run Chinook salmon, spring-run Chinook salmon will likely benefit from this expanded habitat. Additionally, habitat restoration activities are expected to have short-term impacts to habitat from ground and in-water disturbance; however, the restoration is expected to begin improving these PBFs before proposed action operations commence and improve this PBF for all listed salmonids in the long-term.

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. 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. The PA describes the incorporation of refugia along the NDD screens that may provide additional

minimization to screen impingement and associated predation risk. Phased testing and operation of the three NDD intakes will ensure that the screens are functioning to NMFS screening criteria.

The in-Delta flow analysis concludes that there will be adverse effects to CV spring-run Chinook critical habitat in the Delta including impacts to rearing and migratory habitat in this area. Also, availability of rearing habitats in the North Delta is likely to be reduced under the PA because reduced flows downstream of NDD lower the water level, which reduces the inundation index of wetland and riparian benches that serve as rearing habitats. These conclusions indicate that there will be some degradation to the estuarine habitat PBFs for this species. Under the PA, greater frequency of routing into the interior Delta is anticipated, as well as increased Delta travel times, resulting in further degradation to migratory and estuarine habitat PBFs. However, the revised PA unlimited pulse protections will reduce the impact to juvenile migration routing and travel time to some degree.

Taking into account the project impacts to each PBF, as well as the revised PA habitat improvements, the Central Valley spring-run Chinook salmon critical habitat will likely be impacted to a moderate level by the PA, which will be further ensured through adaptive management (as described in Appendix A2).

2.5.2.4.3 CCV Steelhead

Overall, the monthly temperature modeling results, exceedance plots and biological tools all indicate that thermal impacts on the PBFs of CCV steelhead critical habitat that relate to spawning will largely be the same with implementation of either the NAA or PA operations. Adverse thermal effects on these PBFs from changes to upstream operations as a result of the PA are not expected. However, for purposes of the analysis in the Integration and Synthesis section, the combined effect of PA implementation when added to the environmental baseline and modeled climate change impacts is expected to result in substantial degradation to spawning PBFs in critically dry years. The revised PA (Appendix A2), however, includes a recommitment to expanding the available habitat for spawning adults, incubation of eggs, and rearing for fry, specifically in Battle Creek and above Shasta Dam, into the McCloud River. In addition, the revised PA includes 80 acres of expanded rearing habitat through restoration in the upper Sacramento River between Keswick Dam and RBDD and 1,800 acres of tidal rearing habitat restoration in the Delta. Although the target species for these efforts is winter-run Chinook salmon, steelhead will likely benefit from this expanded habitat. Additionally, habitat restoration activities are expected to have short-term impacts to habitat from ground and in-water disturbance; however, the restoration is expected to begin improving these PBFs before proposed action operations commence and improve these PBF for all listed salmonids in the long-term. Projected decreases in both spawning and fry and juvenile rearing WUA will cause a low-level magnitude of degradation to spawning and rearing habitat PBFs. Construction-related effects to critical habitat for this species will be more extensive than for winter-run or spring-run Chinook salmon 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 as a result of construction-related effects from the PA because 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 is expected to degrade the migratory PBFs for CCV steelhead. The PA describes the incorporation of refugia along the NDD screens that may provide additional minimization to screen impingement and associated predation risk. Phased testing and operation of the three NDD intakes will ensure that the screens are functioning to NMFS screening criteria. The in-Delta flow analysis concludes that there will be adverse effects to CCV steelhead critical habitat in the Delta due to NDD operations including impacts to rearing and migratory habitats in this area. However, the revised PA unlimited pulse protections at the NDD will reduce the impact to juvenile migration routing and travel time through the Delta to some degree. Diversions at the existing CVP and SWP export facilities in the south Delta are expected to cause changes in hydrodynamic conditions that are likely to result in some degradation to PBFs associated with estuarine habitat, freshwater rearing and freshwater migratory corridors for juvenile CCV steelhead in the south Delta.

Also, availability of rearing habitats in the north Delta is likely to be reduced under the PA because reduced flows downstream of NDD lower the water level, which reduces the inundation index of wetland and riparian benches that serve as rearing habitats. These conclusions indicate that there will be some degradation to the estuarine habitat PBFs for this species. Additionally, 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 PBFs for CCV steelhead.

Taking into account the project impacts to each PBF, as well as the revised PA habitat improvements, the California Central Valley steelhead critical habitat will likely be impacted to a moderate level by the PA, and adaptive management (as described in Appendix A2) will support this conclusion.

2.5.2.4.4 sDPS Green Sturgeon

The analysis of upstream temperature and flow effects to sDPS green sturgeon critical habitat indicate that PBFs utilized by early life stages will not be degraded as a result of the PA. 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 due to NDD operations and hydrodynamics changes in the south Delta due to ongoing diversions at the existing CVP and SWP export facilities may impact estuarine PBFs for green sturgeon as the availability and/or functionality of benthic habitat utilized by sDPS green sturgeon in the Delta may be impacted by altered hydrologic cues or decreased inundation of

wetland benches. The extent to which the designated critical habitat in the Delta for sDPS green sturgeon will be diminished as a result of in-Delta flow reductions or hydrodynamic changes in the south Delta is currently not well understood.

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

2.6 Cumulative Effects

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

Some continuing non-Federal activities are reasonably certain to contribute to climate effects within the action area. However, it is difficult if not impossible to distinguish between the action area's future environmental conditions caused by global climate change that are properly part of the environmental baseline *vs.* cumulative effects. Therefore, all relevant future climate-related environmental conditions in the action area are described in the environmental baseline (Section2.4).

2.6.1 Unscreened Water Diversions

Water diversions for irrigated agriculture, municipal and industrial use, and managed wetlands are found throughout the California Central Valley. Thousands of small and medium-size water diversions exist along the Sacramento River, San Joaquin River, their tributaries, and the Delta, and many of them remain unscreened. Depending on the size, location, and season of operation, these unscreened diversions entrain and kill many life stages of aquatic species, including juvenile listed anadromous species (Mussenet al. 2013, Mussen et al.2014). For example, as of 1997, 98.5 percent of the 3,356 diversions included in a Central Valley database were either unscreened or screened insufficiently to prevent fish entrainment (Herren and Kawasaki 2001).Most of the 370 water diversions operating in Suisun Marsh are unscreened(Herren and Kawasaki 2001).

2.6.2 Agricultural Practices

Agricultural practices may negatively affect riparian and wetland habitats through upland modifications that lead to increased siltation or reductions in water flow in stream channels flowing into the action area, including the Sacramento River and Delta. Grazing activities from dairy and cattle operations can degrade or reduce suitable critical habitat for listed salmonids by increasing erosion and sedimentation, as well as introducing nitrogen, ammonia, and other nutrients into the watershed, which then flow into receiving waters. Stormwater and irrigation discharges related to both agricultural and urban activities contain numerous pesticides and herbicides that may disrupt various physiological mechanisms and may negatively affect reproductive success and survival rates of listed anadromous fish(Scott and Sloman 2004).