same period. During the 75 day pumping reduction from March 15 to May 31 and the 30 day no pumping period (April 1 to April 30), the effects of the CCWD action is significantly reduced or eliminated. In addition, Rock Slough is not part of designated critical habitat for green sturgeon (74 FR 52300).

5.4.1.2.2.9.2 Clifton Court Forebay Aquatic Weed Control Program

As described by NMFS (2009: 387-388), juvenile and sub-adult green sturgeon are recovered year-round at the CVP/SWP facilities, albeit in low numbers, and have higher levels of salvage during the months of July and August compared to the other months of the year. The reason for this distribution is unknown at present. Therefore, juvenile and sub-adult green sturgeons are likely to be present during the application of the herbicides as part of the aquatic weed control program, and could be exposed to mechanical removal efforts occurring on an as-needed basis.

5.4.1.3 Assess Species Response to the Proposed Action

The response of listed salmonids and green sturgeon to the proposed action is discussed in this section, with the potential effects divided into near-field and far-field effects. Near-field effects are those occurring close to an operations facility, e.g., predation at the NDD screens or the HOR gate. Far-field effects are those occurring over a broader area, e.g., lower through-Delta survival caused by less river flow downstream of the NDD.

5.4.1.3.1 Salmonids

5.4.1.3.1.1 Near-Field Effects

5.4.1.3.1.1.1 North Delta Exports

As described in Section 3.2.2.2, *Fish Screen Design*, the NDD will be provided with fish screens designed to minimize the risk that fish will be entrained into the intakes, or injured by impingement on the fish screens. The process of the fish screen design has been and will continue to be subject to extensive collaborative discussions with the fish agencies affecting both final design and initial operations of the screens, during which their operations will be “tuned” to minimize risks to fish. As also described in Section 3.4.8 *Monitoring and Research Program*, a number of studies will be conducted to monitor NDD fish screen performance and allow refinement to meet design criteria.

5.4.1.3.1.1.1.1 Entrainment

Juvenile Chinook salmon at sizes of 30 mm or greater may occur near the north Delta intake structures (National Marine Fisheries Service 1997). Juvenile steelhead migrating downstream in the Sacramento River that will be exposed to the north Delta intakes typically range in length from approximately 150 to 250 mm. Based on a conservative body fineness ratio of 10 (from Delta Smelt estimates by Young et al. 1997) and applying the equations of Young et al. (1997), the NDD’s fish screens with a 1.75-mm opening would be estimated to be effective at excluding juvenile Chinook salmon of 22-mm standard length and greater, as well as juvenile steelhead, which generally are larger than Chinook salmon during their Delta residence (McEwan 2001). Therefore, little to no entrainment of salmonids is expected at the proposed north Delta diversions. Note, however, that one juvenile Chinook salmon of 32-mm fork length—standard length would be slightly shorter—was collected during entrainment monitoring at the Freeport Regional Water Project intake in January 2012 (Kozlowski pers comm.), a facility with the same screen opening size as proposed for the NDD. This suggests occasional entrainment of very

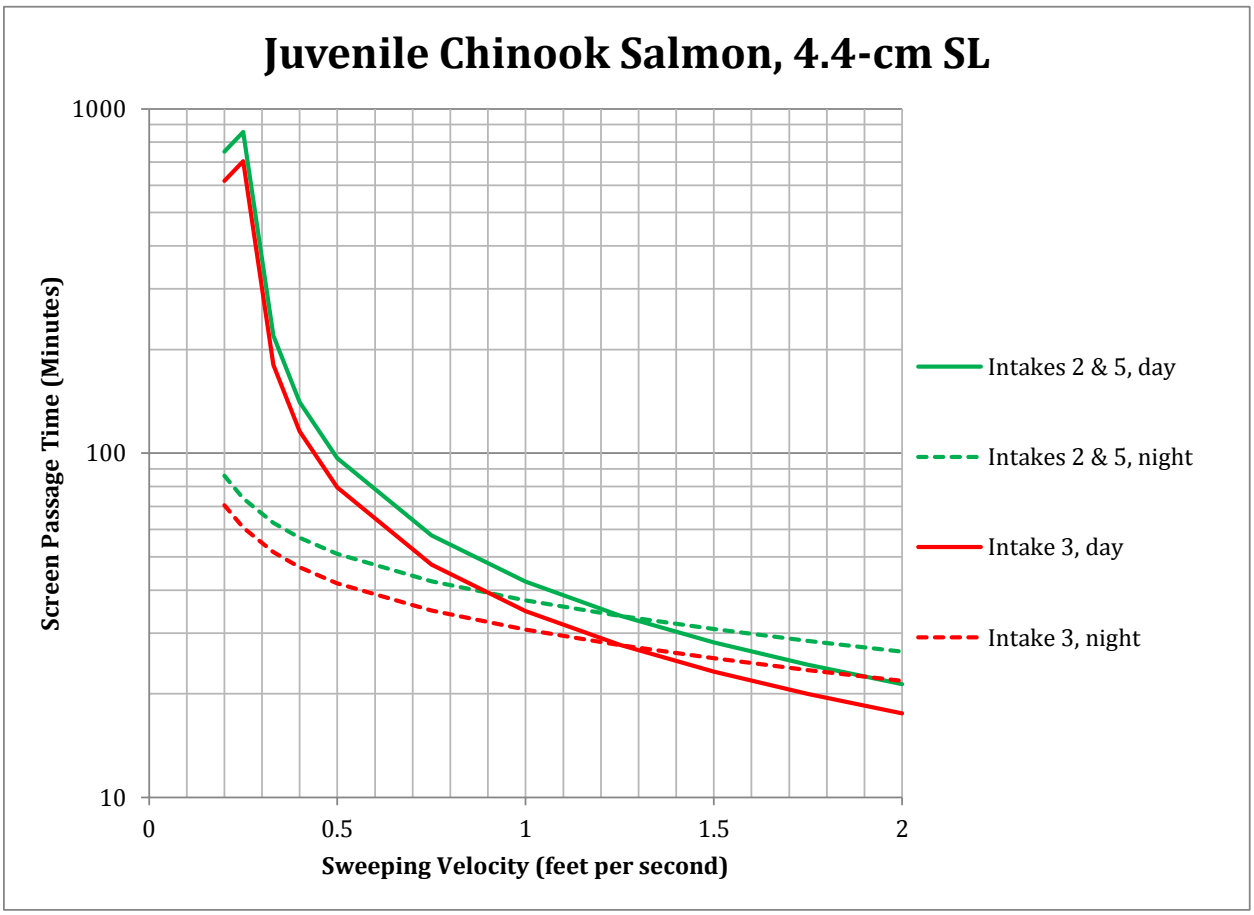
small Chinook salmon could occur at the north Delta intakes, although most would be expected to be excluded.

5.4.1.3.1.1.1.2 Impingement, Screen Contact, and Screen Passage Time

Juvenile salmonids would have the potential to contact and be impinged on the screens of the NDD. Experimental studies at the UC Davis Fish Treadmill facility found that Chinook salmon experienced frequent contact with the simulated fish screen but were rarely impinged (defined as prolonged screen contacts >2.5 minutes) and impingement was not related to any of the experimental variables examined (Swanson et al. 2004a). The extent to which the relatively benign experimental environment is representative of Sacramento River conditions is uncertain, but the proposed NDD intake screens would have a smooth screen surface and the potential for frequent screen cleaning (cycle time no more than 5 minutes), which would provide additional protection to minimize screen surface impingement of juvenile Chinook salmon and steelhead. The smooth surface also would serve to reduce the risk of abrasion and scale loss for any fish that does come into contact with the screens (Swanson et al. 2004a).

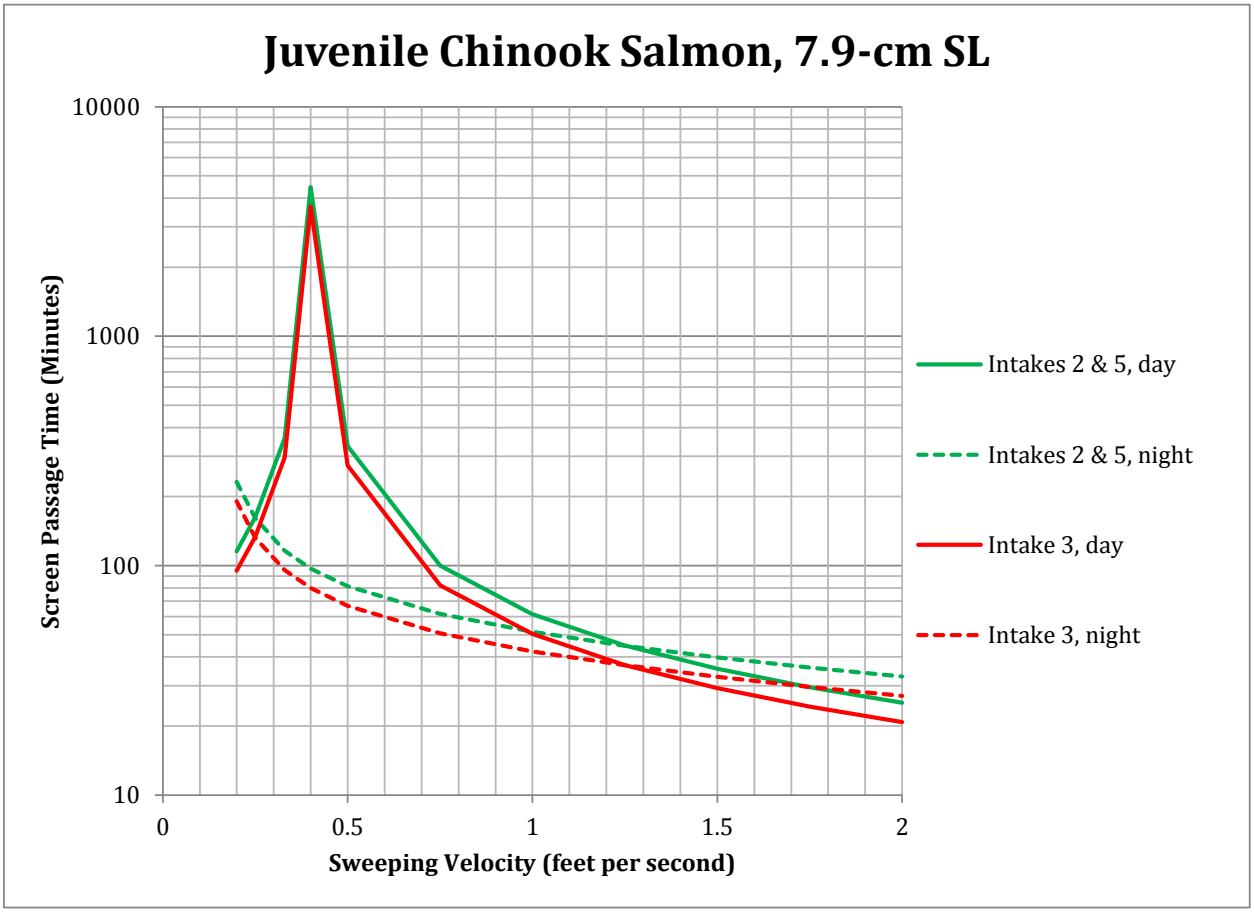
Although Swanson et al. (2004a) provide equations to estimate screen contact rate for juvenile Chinook salmon, preliminary calculations for this effects analysis suggested that these equations did not perform well for the lengths of screen proposed for the NDD. Additionally, the equations derived from this study, conducted in a two-foot wide channel, may not be wholly applicable to the effects of NDD, where fish will be in a much wider channel and may be able to move away from the screens or may not be in an area of the channel exposed to their effects. Screen passage time is another useful measure of potential effects on Chinook salmon, with shorter passage times being more desirable to limit the potential for adverse effects (e.g., predation or screen contact). Application of the relationships from Swanson et al. (2004a) for a representative winter water temperature of 12°C illustrated how screen passage time may differ in relation to sweeping velocity at an approach velocity of 0.2 ft/s (see methods description in Appendix 5.D, *Quantitative Methods and Detailed Results for Effects Analysis of Chinook Salmon, Central Valley Steelhead, Green Sturgeon, and Killer Whale*, Section 5.D.1.1.1.1, *Screen Passage Time*) (Figure 5.4-1 and Figure 5.4-2). It should be noted that the equations of Swanson et al. (2004a) give very long screen passage times at certain sweeping velocity and approach velocity combinations, e.g., over 4,600 minutes for 7.9-cm fish along intakes 2 and 5 at sweeping velocity of 0.4 ft/s (Figure 5.4-2). Such estimates are far in excess of the duration of the experimental trials (120 minutes) used to derive the swimming data and therefore should be treated with caution. The peaks in the estimated screen passage times shown in Figure 5.4-1 and Figure 5.4-2 reflect the swimming response of the tested juvenile Chinook salmon and their general negative rheotaxis (swimming against the prevailing current). To the left of the peaks, swimming velocity was sufficient to give net upstream progress, so that in theory the fish would pass the screen in an upstream direction. To the right of the peaks, swimming velocity increases but does not keep up with the increase in sweeping velocity, resulting in fish passing the screen in a downstream direction. Very high estimated screen passage time at the peaks reflects fish that would be maintaining station in front of a screen for a long time. Larger fish have greater swimming ability, so their peak screen passage time is somewhat greater (Figure 5.4-2) than that of smaller fish (Figure 5.4-1). Swimming velocity is lower at night than during the day for a given set of flow conditions; this generally results in screen passage time decreasing as sweeping velocity increases over the full range of sweeping flows examined here, because screen passage velocity

becomes more negative (i.e., fish move downstream more quickly). Longer screens increase screen passage time: for example, at a sweeping velocity of 0.4 ft/s during the night, a 7.9-cm juvenile would pass the screens of intakes 2 and 5 (each ~1,350 feet long) in ~97 minutes, compared to ~80 minutes for intake 3 (1,100 feet long) (Figure 5.4-1 and Figure 5.4-2). Juvenile salmonids migrating downstream close to shore may encounter several of the proposed intakes within a few hours, depending on travel time. Because of the lack of an established relationship between passage time, screen contact rate and injury or mortality, it is not possible to conclude with high certainty what the effects of the NDD may be on juvenile Chinook salmon or indeed on juvenile steelhead, which Swanson et al. (2004a) noted behaved similarly in the Fish Treadmill tests. This uncertainty would be addressed with monitoring and targeted studies examining impingement and passage time along the intakes. Swanson et al. (2004a) also found that at warmer temperatures (19°C), the larger fish had a greater tendency to move downstream with the current (negative rheotaxis), consistent with a behavioral shift to outmigration; this would result in considerably lower screen passage times.



Note: The total screen length for intakes 2 and 5 would be 1,350 feet each; intake 3's screen length would be 1,110 feet.

Figure 5.4-1. Estimated Screen Passage Time for Juvenile Chinook Salmon (4.4-cm Standard Length) Encountering Proposed NDD Fish Screens at Approach Velocity of 0.2 Feet per Second during the Day and Night.



Note: The total screen length for intakes 2 and 5 would be 1,350 feet each; intake 3's screen length would be 1,110 feet.

Figure 5.4-2. Estimated Screen Passage Time for Juvenile Chinook Salmon (7.9-cm Standard Length) Encountering Proposed NDD Fish Screens at Approach Velocity of 0.2 Feet per Second during the Day and Night.

5.4.1.3.1.1.1.3 Predation

Predation of juvenile salmonids at the NDD could occur if predatory fish aggregated along the screens, as has been observed at other long screens in the Central Valley (Vogel 2008b). The only study of predation along a long fish screen occurred at the Glenn Colusa Irrigation District's (GCID) Sacramento River pump station (Vogel 2008b). In that study, mean survival of tagged juvenile Chinook salmon along the fish screens (total length just under 1,300 feet) in 2007—this being the only year of the study in which flow-control blocks at the weir at the downstream end of the fish screen were removed, to reduce predatory fish concentration—was ~95%. However, the percentage of tagged juvenile Chinook salmon released at the upstream end of the fish screen that were recaptured at a downstream sampling location was similar or slightly greater than for fish released at the downstream end of the fish screen, when standardized for the distance that the fish had to travel to the recapture site. These data suggest that survival along the screen was at least similar to survival in the portion of the channel without the screen (i.e., screen survival was similar to baseline survival, if the latter is assumed to be represented by the channel downstream of the screen). However, test fish providing the estimate of survival in the channel

downstream of the screen were released prior to the fish that were released at the upstream end of the fish screen, which could have confounded comparisons of relative survival between these groups if predatory fishes became partly satiated prior to the arrival of the fish released at the upstream end of the screen (thus making their survival relatively higher than otherwise would have occurred) (Vogel 2008b).

Although the GCID facility is closest in size to the proposed NDD and has received considerable study in terms of fish survival, the GCID facility and the proposed NDD screens are substantially different. The GCID facility is located along a relatively narrow oxbow channel (about 10 to 50 meters wide) in the middle Sacramento River near Hamilton City, while the north Delta intakes would be located on the much wider channel of the mainstem lower Sacramento River (about 150 to 180 meters wide). In addition, the fish tested at GCID were relatively small (mean length generally less than 70 mm; Vogel 2008b) in comparison to the sizes of salmonid that would occur near the NDD (e.g., winter-run Chinook salmon mean length generally would be greater than 70 mm; del Rosario et al. 2013), which could give different susceptibility to predation. Under the PA, there would be three intakes constituting the NDD, compared to only one for the GCID facility, so that the cumulative length of screen would be considerably greater for the PA. Therefore, there is uncertainty to what extent the results from the GCID studies may represent the situation at the NDD.

Analysis of potential predation of juvenile Chinook salmon using a bioenergetics approach (see the public draft BDCP's Appendix 5.F, *Biological Stressors on Covered Fish*, Section 5.F.3.2.1 [California Department of Water Resources 2013]) suggested that loss along the NDD[9] would be an order of magnitude lower than estimated at the GCID facility (e.g., for winter-run Chinook salmon the bioenergetics estimates were considerably less than 0.3%). These estimates are uncertain because of the various assumptions in the modeling and do not provide context for how such losses would compare to baseline losses without the NDD. Overall, there is potential for predation of juvenile salmonids along the NDD, which would constitute an adverse effect. Implementation of the conservation measure to undertake localized reduction of predatory fishes at the NDD could reduce the potential for predation, although this measure is uncertain in its effectiveness. Further discussion is provided in Section 5.5.2, *Localized Reduction of Predatory Fishes to Minimize Predator Density at North and South Delta Export Facilities*.

5.4.1.3.1.1.2 South Delta Exports

As described by NMFS (2009: 341-374), direct entrainment of juvenile winter-run Chinook salmon, spring-run Chinook salmon, and Central Valley steelhead includes a number of components contributing to loss. These include the following.

- SWP
    - Prescreen loss (from Clifton Court Forebay radial gates to primary louvers at the Skinner Fish Protection Facility): 75% loss
    - Louver efficiency: 25% loss

[9] Although the screen lengths analyzed were different to those proposed under the PA, the order of magnitude of the results would remain the same if modeling specific to the PA was undertaken.