flow (NMFS 2012). The barrier is fitted with culverts to allow a minimum of approximately 500 cfs to flow into Old River. HORB is installed in mid-September, at the discretion of CDFW, and is completely removed by November 30. Throughout this period, the barrier is notched to allow for the upstream passage of adult salmon and steelhead (NMFS 2012). Unlike the agricultural barriers, the HORB is not submerged at high tide.

Installation of the south Delta agricultural barriers reduces tidal exchange in the south Delta. The barriers create a delay in the tidal signal and difference in elevation between the channels upstream and downstream of the barriers. Installation of the HORB reduces net flows into Old River (NMFS 2012). There is evidence that the presence of the HORB magnifies negative OMR flows, thus increasing entrainment of Delta smelt (NMFS 2009b). This can occur when water that is blocked by the HORB from entering Old River proceeds down the San Joaquin River and then is drawn into Old and Middle Rivers toward the CVP and SWP diversion points.

Areas of null flows (flows with no net upstream or downstream motion) can occur in the interior sections of the south Delta channels. Null flows become more common when south Delta irrigation demands are high and inflow from the San Joaquin River is low (e.g., when HORB is in place). The flow patterns in the interior of the south Delta under these conditions create a "hydraulic trap" for particles (or fish) moving with the river's flow. These null flow areas are also associated with low DO and poor water quality (NMFS 2012).

2.4.4 Delta Cross Channel Gate Operations

The DCC is a controlled diversion built in 1951, located in Walnut Grove and operated and maintained by the San Luis Delta-Mendota Water Authority at the direction of Reclamation. The gates have a physical capacity of 3,500 cfs and can divert a significant portion of the Sacramento River flows into the eastern Delta (State Water Board 2010). Flows are controlled by gates that are normally kept open to maintain cross-Delta flows. The DCC gates are closed in the late summer and autumn, to facilitate salmon emigration (Monsen et al. 2007). The DCC significantly affects Delta hydrodynamics by sending Sacramento River water into Snodgrass Slough and the North Fork Mokelumne River and then to the interior Delta (Reclamation 2006). This diversion significantly improves water quality in the southern Delta and at the export pumps, but also increases the probability of entrainment of juvenile salmon migrating past its gates into the interior Delta, resulting in lower survival. When the gates are open, 40–50 percent of the Sacramento River flow enters the interior Delta via the DCC and Georgiana Slough. When the gates are closed, only 15–20 percent of the Sacramento River flow enters the interior Delta (Low et al. 2006). The gates are closed during migration periods to protect Chinook salmon and also at high flows to prevent flooding (Reclamation 2006). The effect of the DCC on fish is discussed in more detail in Section 3.4.5, *Flow Effects on Salmonids*.

Closure of the DCC gates alters the circulation in the north Delta by directing more Sacramento River water down its main stem and away from the central Delta. This closure results in less freshwater available to prevent salinity intrusion on the San Joaquin River stem of the Delta. While salinity will decrease at Emmaton on the Sacramento River, salinity will increase on the San Joaquin at Jersey Point (Monsen et al. 2007).