Section 6.1

6.1 Fish

Introduction

This assessment covers species within aquatic environments potentially affected by the SDIP, including the Sacramento, American, Feather, San Joaquin, and Trinity Rivers, the Delta, and Suisun Bay. Although many fish species occur within the affected aquatic environment, the assessment focuses on Central Valley fall-/late fall–run Chinook salmon (ESA, ~~candidate~~species of concern), Sacramento River winter-run Chinook salmon (ESA and CESA, endangered), Central Valley spring-run Chinook salmon (ESA and CESA, threatened), Southern Oregon/northern California coasts coho salmon (ESA and CESA, threatened), Central Valley steelhead (ESA, threatened), delta smelt (ESA and CESA, threatened), splittail (ESA, listing withdrawn), striped bass (an important sport fish), and green sturgeon (ESA, ~~proposed~~ threatened). The response of the selected species to project actions provides an indicator of the potential response of other species. The full range of environmental conditions and fish habitat elements potentially affected is encompassed by the assessment for the species specifically discussed.

This section includes the following information:

- a summary of significant impacts that could result from implementation of the SDIP alternatives;
- a description of the affected environment, including the life histories and existing environmental conditions for factors that may affect the abundance and survival of the selected species;
- a description of the assessment methods that were used to evaluate potential impacts of the SDIP alternatives; and
- a description of the effects (i.e., environmental consequences) for each SDIP alternative on fish and fish habitat, including identification of significant impacts and measures to mitigate significant impacts.

Summary of Significant Impacts

Implementation of the SDIP alternatives includes construction and operation of gates in the south Delta, dredging, and water supply operations that affect fish and fish habitat in the Delta and rivers upstream of the Delta. Construction of the gates results in less-than-significant impacts because environmental commitments (Chapter 2, "Project Description") and BMPs will be implemented and the area disturbed by construction of gates would be similar to the existing footprint of the temporary barriers. Operation of the permanent gates would have less-than-significant impacts given that effects on net and tidal flow would be similar to conditions with the existing temporary barriers, and operability would increase flexibility to minimize existing effects. Dredging would increase channel depth, but habitat area and quality would be similar to pre-dredged that were included in the calculations of habitat conditions for the SDIP alternatives. Actual occurrence and relative abundance may vary between months and from year to year.

Chinook Salmon

After 2–5 years in the ocean, adult Chinook salmon leave the ocean and migrate upstream in the Sacramento and San Joaquin rivers. The names of the Chinook salmon runs (i.e., fall, late fall, winter, and spring) reflect the variability in timing of the adult life stage (Table 6.1-2). Spawning occurs in the cool reaches of Central Valley rivers that are downstream of the terminal dams and in tributary streams. After the eggs hatch, juvenile Chinook salmon remain in fresh water for 3–14 months.

Historical records indicate that adult spring-run Chinook salmon enter the mainstem Sacramento River in March, and continue to their spawning streams where they hold until September in deep cold pools (Table 6.1-2). Spring-run Chinook salmon are sexually immature during their spawning migration. Spawning occurs in gravel beds in late August through October, and emergence begins in December. Spring-run Chinook salmon migrate downstream as young-of-year or yearling juveniles. Young-of-year juveniles move between February and June, and yearling juveniles migrate from October to March, with peak migration in November (Cramer, S.P. 1996).

Adult fall-/late fall–run Chinook salmon enter the Sacramento ~~and San Joaquin~~ River ~~systems~~ from July through February and spawn from October through March (Table 6.1-2). Adult fall-run Chinook salmon enter the San Joaquin River tributaries from October to December and spawn during these months (Table 6.1-2) (Baker and Morhardt 2001). Optimal water temperatures for egg incubation is 44 to 54°F (6.7 to 12.2°C) (Rich 1997). Newly emerged fry remain in shallow, lower-velocity edgewaters (California Department of Fish and Game 1998). Sacramento River j~~J~~uveniles migrate to the ocean from October to June and San Joaquin River juveniles migrate from late February through June (Baker and Morhardt 2001)(Table 6.1-2).

Adult winter-run Chinook salmon leave the ocean and migrate through the Delta into the Sacramento River from December through July (Table 6.1-2). Adults migrate upstream past RBDD on the Sacramento River from mid-December through July, and most (85%) of the spawning population has passed RBDD by mid-May, trailing off in late June (Table 6.1-2). Spawning takes place from mid-April through August, and incubation continues through October (Table 6.1-2). The primary spawning grounds in the Sacramento River are above RBDD. Juvenile winter-run Chinook salmon rear and migrate in the Sacramento River from July through March (Hallock and Fisher 1985; Smith pers. comm.). Juveniles move downstream in the Sacramento River above RBDD from August through October and possibly November, rearing as they move downstream. Juveniles have been observed in the Delta during October through December, especially during high Sacramento River discharge in response to fall and early-

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winter storms. Winter-run salmon juveniles migrate through the Delta to the ocean from December through as late as May (Stevens 1989).

During spawning, the female digs a redd (a nest in clean gravel) and deposits eggs. A male fertilizes the eggs during the creation of the redd. Optimal water temperature for egg incubation is 44 to 54°F (6.7 to 12.2°C) (Rich 1997). Newly emerged fry remain in shallow, lower-velocity edgewaters (California Department of Fish and Game 1998). Juveniles rear in their natal streams, the mainstem of the Sacramento River, and in the Delta.

Cover, space, and food are necessary components for Chinook salmon rearing habitat. Suitable habitat includes areas with instream and overhead cover in the form of cobbles, rocks, undercut banks, downed trees, and large, overhanging tree branches. The organic materials forming fish cover also provide sources of food, in the form of both aquatic and terrestrial insects.

Juvenile Chinook salmon move downstream in response to many factors, including inherited behavior, habitat availability, flow, competition for space and food, and water temperature. The number of juveniles that move and the timing of movement are highly variable. Storm events and the resulting high flows appear to trigger movement of substantial numbers of juvenile Chinook salmon to downstream habitats. In general, juvenile abundance in the Delta appears to be higher in response to increased flow (U.S. Fish and Wildlife Service 1993).

Steelhead

Steelhead have one of the most complex life histories of any salmonid species. Steelhead are anadromous, but some individuals may complete their life cycle within a given river reach. Freshwater residents typically are referred to as rainbow trout, while anadromous individuals are called steelhead (National Marine Fisheries Service 1996a).

Historical records indicate that adult steelhead enter the mainstem Sacramento River in July, peak in abundance in September and October, and continue migrating through February or March (Table 6.1-2) (McEwan and Jackson 1994; Hallock 1989). Most steelhead spawn from December through April (Table 6.1-2), with most spawning occurring from January through March. Steelhead have been captured in the San Joaquin River tributaries, but their populations are small (McEwan 2001). The timing of adult migration in the San Joaquin is unknown, but may be similar to the Sacramento River fish. Unlike Pacific salmon, some steelhead may survive to spawn more than one time, returning to the ocean between spawning migrations.

The female digs a redd in which she deposits her eggs. The duration of egg incubation in the gravel is determined by water temperature, varying from approximately 19 days at an average water temperature of 60°F (15.6°C) to approximately 80 days at an average temperature of 40°F (4.4°C). Steelhead fry usually emerge from the gravel 2 to 8 weeks after hatching (Barnhart 1986;

Reynolds et al. 1993). Newly emerged steelhead fry move to shallow, protected areas along streambanks and move to faster, deeper areas of the river as they grow. Most juveniles occupy riffles in their first year of life and some of the larger steelhead live in deep fast runs or in pools. Juvenile steelhead feed on a variety of aquatic and terrestrial insects and other small invertebrates.

Juvenile migration to the ocean generally occurs from December through ~~August~~ June (Table 6.1-2). Most Sacramento River steelhead migrate in spring and early summer (Reynolds et al. 1993). Sacramento River steelhead generally migrate as 1-year-olds at a length of 6 to 8 inches (15.2 to 20.3 centimeters [cm]) (Barnhart 1986; Reynolds et al. 1993). Most juvenile steelhead ~~Although steelhead have been~~ are collected ~~in most months~~ at the state and federal pumping plants in the Delta from January through June, with the peak numbers salvaged at these facilities ~~occur~~ in March and April ~~in most years~~ (Foss 2004). A few juvenile steelhead are captured in the eastside tributaries of the San Joaquin (McEwan 2001) and their timing may be similar to the Sacramento River.

After 2–3 years of ocean residence, adult steelhead return to their natal stream to spawn as 3- or 4-year-olds (National Marine Fisheries Service 1998).

Coho Salmon

Coho salmon are anadromous fish that migrate as adults into the Trinity River and other coastal streams and rivers to spawn. Adult migration occurs from mid-September through December, when water temperatures are from 39 to 57°F (4 to 14°C) and spawning typically takes place between November and January (Table 6.1-2) (Moyle 2002). Coho salmon adults spawn in waters with velocities of 0.82–1.0 feet/sec (0.25–0.31 meter per second (m/sec) and depths of 11.8–12.2 inches (0.3–0.31 meter) (Hampton 1988). Redds are formed near the heads of riffles in medium-to-small gravel that provide good flow and aeration. Spawning occurs over about a week. Optimal embryo development takes place when water temperatures are 40 to 55°F (4.4 to 13°C) (Emmett et al 1991, 137). Embryos hatch after 8–12 weeks depending on the water temperature, and remain in the gravel for 4–10 weeks until their yolk sacs are absorbed (Leidy and Leidy 1984). Eggs and aelvins have been observed in water temperatures from 40 to 70°F (4.4 to 21°C (Emmett et al 1991, 137). After hatching, the juveniles move to shallow water along the stream margins (Moyle 2002).

Habitat includes backwaters, side channels, and stream margins adjacent to large, slow runs or pools. Coho salmon will shift their habitat use depending on the season, but use mostly deep pools with overhead cover in the summer (Moyle 2002). Cover is the most important rearing habitat feature; coho salmon seek areas with overhanging vegetation (e.g., brush and logs) and thick clusters of aquatic vegetation (Hampton 1988). Optimal growth temperature ranges from 53.1 to 57°F (11.7 to 13.9°C), and they prefer velocities of 0.3 to 1.5 feet/sec (0.09 to 0.46 m/sec) (Moyle 2002). Juveniles are absent from tributaries that reach temperatures warmer than 64°F (17.8°C) for more than a week.

pThe certainty of the assessment relationship is low, primarily because specific data on steelhead spawning in the Sacramento, Feather, and American Rivers are not extensive. Also, the magnitude of species response is weakly supported. It is possible that spawning habitat is not limiting and that the assessment overstates the habitat need. Adequate flows for spawning and incubation have been defined in previous years within different rivers. Flows can be used as a baseline to predict spawning and post-spawning success, but additional habitat measurements such as depth, velocity, spawning gravel quality, and water temperature are necessary for successful spawning and incubation. Flow-habitat relationships for steelhead are also substantially different from the relationships for Chinook salmon because substrate, depth, and velocity preferences differ. As with Chinook salmon, the relationships assume saturation of the spawning habitat. More detailed evaluation of the magnitude of effects and other aspects of the relationships is warranted.

Delta Smelt

The assessment of changes Delta inflow on delta smelt spawning habitat is based on the hypotheses that reduction in spawning habitat will result in reduced larval production. Implementation of the SDIP is unlikely to substantially affect environmental conditions (i.e., fresh water) that maintain the existing habitat area in the Delta. The extent of salinity intrusion into the Delta, as represented by the change in the location of X2, will be evaluated to ~~confirm~~ determine if there is an ~~minimal~~ effect on spawning habitat area.

The certainty of the assessment relationship is minimal. Existing information does not indicate that spawning habitat is limiting. Very little is known about spawning habitat needs of delta smelt; therefore, the assumption that spawning habitat is not limiting is speculative. Spawning occurs in fresh water, based on collection of ripe females and larval catches. In drier years, most female and larval delta smelt have been found in the Sacramento River near Prospect Island and the Barker-Lindsey–Cache Slough complex (Wang and Brown 1993). In high outflow years, smelt are found in most of the Delta, Suisun Marsh, and the Napa River (Sweetnam 1999). In addition to poor understanding of spawning location, the primary spawning substrate in the Delta is unknown. Eggs are adhesive, and suitable substrate may be aquatic vegetation, rocks, or instream woody material (Moyle 2002).

Splittail

The assessment is based on the hypothesis that inundation of floodplain and bypasses during high flow years is needed to maintain population abundance. Change in spawning habitat area is assumed to result in a medium level of response—a change in spawning habitat area results in a proportional change in fry abundance.

Spawning habitat availability is dependent on inundation of floodplain and flood bypasses during January through April. The assessment is based on Sacramento River flow conditions that inundate the Sutter and Yolo Bypasses, the primary spawning areas for splittail. The Sutter Bypass is substantially inundated when Sacramento River flow near Colusa is greater than 25,000 cfs. The Yolo Bypass

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to 3.0 feet msl two times each day. The maximum change in SWP pumping (and CCF operations) could reduce the daily higher high tide from about 2.6 to 2.4 feet msl near the CCF gates (Section 5.2, Delta Tidal Hydraulics; Figures 5.2-60 through 5.2-62). The reduction in higher high tide attributable to change in SWP pumping is less with distance from the CCF gates. When closed during tide levels below 0.0 feet msl, the flow control gates block fish passage. When opened during tide levels greater than 0.0 feet msl, fish passage is restored. The volume of water exchanged during each tidal cycle is reduced by about 20% for the channels upstream of the gates on Middle River, Grant Line Canal, and Old River.

During the spring, the head of Old River fish control gate would be operated to block flow and movement of juvenile fall-run Chinook salmon and other fishes from the San Joaquin River into Old River from about April 15 through May 15, but could be operated as early as April 1 and extend through June 1. Juvenile Chinook salmon and juvenile steelhead begin migrating downstream before April 1 and may be vulnerable to entrainment. , or Closure of the Old River fish control gate before April 1 will be considered other periods as recommended by USFWS, NOAA Fisheries, and DFG (Table 6.1-12). Juvenile Chinook salmon move down the San Joaquin River past Stockton, a pathway believed to enhance survival relative to movement into Old River (Brandes and McLain 2001).

During fall, the head of Old River fish control gate would be operated to increase flow in the San Joaquin River past Stockton from about September 15 through November 30 or other periods as recommended by USFWS, NOAA Fisheries, and DFG. The increased flow in the San Joaquin River potentially improves water quality, including increased DO, in the San Joaquin River channel near Stockton (Giulianotti et al. 2003). Improved water quality could benefit upstream migrating adult Chinook salmon.

Chinook Salmon

The following assessment identifies potential construction-related impacts of implementing Alternative 2A on winter-, spring-, and fall-/late fall–run Chinook salmon in Central Valley rivers and the Delta. The assessment also identifies the impacts on Chinook salmon as a result of operating the gates. The environmental conditions affected under Alternative 2A were briefly discussed above. This section assesses the potential effects of those changes on survival, growth, fecundity, and movement of specific life stages for each run.

Impact Fish-1: Construction-Related Loss of Rearing Habitat Area for Chinook Salmon. Chinook salmon rear in the Delta. Construction of the gates in the south Delta and maintenance activities have the potential to permanently modify shallow vegetated areas that may provide rearing habitat for Chinook salmon. The area of shallow vegetated habitat affected by the gate footprints, riprapped levee, and dredging may total several acres (Table 6.1-12; Chapter 2, "Project Description," and Section 5.6, Sediment Transport).

The permanent gates constructed under Alternative 2A would have minimal effect on habitat within the construction footprint at the head of Old River, Predation associated with the addition of the operable gates and the agricultural intake extensions to the south Delta channels could cause a small and likely negligible (i.e., less-than-significant impact) increase in mortality of the juvenile Chinook salmon moving past the structures. The determination is based on several factors. Design elements will minimize turbulence that could disorient fish and increase vulnerability to predation. The structures would not create conditions that could concentrate juvenile Chinook salmon. Flow velocity would be similar to velocities within the channel upstream and downstream of the gates and agricultural intake extensions.

The transition zones between various elements of the gates (e.g., sheetpiles and riprap) could provide low-velocity holding areas for predatory fish. Predatory fish holding near the gates and agricultural intakes could prey on vulnerable species. The additional predator habitat created by the gates and intake extensions would have a less-than-significant impact on juvenile Chinook salmon because the increase in potential predator habitat is small relative to habitat in adjacent areas, including the habitat currently created by the temporary barriers and habitat at the existing agricultural intakes. Disorientation and concentration of juvenile fish would be minimal given the size and design of the gates. This impact is less than significant. No mitigation is required.

Impact Fish-6: Effects of Gate Operation on Juvenile and Adult Chinook Salmon Migration. The head of Old River fish control gate could be closed from April 14 to May 15 under Alternative 1 and could be closed from April 1 to May 31 under Alternative 2A (i.e., when San Joaquin River flow is less than 10,000 cfs) (Table 6.1-12), depending on decisions made by the GORT. Under Alternative 1 (No Action), a temporary fixed barrier is constructed each year. Under Alternative 2A, an operable gate would be constructed ~~with operable gates~~ that would allow a range of operations. Gate closure would minimize the movement of juvenile Chinook salmon into Old River. At a minimum, the gate would be closed during the same VAMP period (April 15 through May 15) as under Alternative 1, but the closure period could begin as earlier and end later as decided by the GORT to respond to real-time conditions. Although the effects of gate closure are similar for both Alternatives 1 and 2A, the operable gate constructed under Alternative 2A would provide increased opportunities (i.e., longer closure) for fish protection. The increased flexibility to operate the fish control gate is also considered a beneficial impact. The extent of this benefit depends on operations decided on by the GORT.

The head of Old River fish control gate may also provide benefits to adult Chinook salmon during upstream migration in September, October, November, and other months (Table 6.1-12). Hallock (1970) observed that adult Chinook salmon avoided water temperatures greater than 66°F if DO was less than 5 mg/l. Low DO in the San Joaquin River channel near Stockton may delay migration of fall-run Chinook salmon. High San Joaquin River flows past Stockton maintain higher DO levels (Hayes and Lee 2000). Closure of the head of Old River fish control gate increases the San Joaquin River flow past Stockton, but the increase in flow during years with low-to-average flow (less than 1,000 cfs) appears to have minimal effect on DO levels. Available data indicate that the operation of flow control gates could reduce DO in the San Joaquin River near Stockton during the summer, but closure of the head of Old River fish control gate September 15 through November 30 would result in DO levels that are the same for Alternatives 1 and 2A (Section 5.3, Water Quality; Figure 5.3-44). Migration of adult Chinook salmon would be protected. Although the benefit of closing the head of Old River fish control gate to upstream movement of adult fall-run Chinook salmon is uncertain for all flow conditions, an operable gate constructed under Alternative 2A would provide increased opportunities to evaluate the potential effects of increased flow under a wide range of San Joaquin River flow conditions (Table 6.1-12). The increased flexibility of an operable gate is a beneficial impact.

Gates in Middle River, Grant Line Canal, and Old River near Byron could affect access to rearing habitat in the south Delta channels and passage through the channels by adult and juvenile Chinook salmon during operation from April 15 through November and other months as needed (Table 6.1-12). Operation of the gates, however, generally avoids the period of adult and juvenile Chinook salmon movement through the Delta, except during May and June when juvenile Chinook salmon could be affected. During May, the proposed closure of the head of Old River Gate would transcend the effects of the gates on Middle River, Grant Line Canal, and Old River near Byron. In addition, the gate operations would have a beneficial effect relative to the existing temporary barriers. The existing temporary barriers are in place from mid-May through September and may also be in place in April to mid-May and in October and November, although the culverts on the Grant Line Canal barrier are tied open. Tidal flow overtops the barriers twice each day during the portion of tide that exceeds 1 foot msl. High tide approaches 3 feet msl, and total tidal volume in the channels upstream of the barriers is reduced by about 50% (Section 5.2, Delta Tidal Hydraulics). The gates constructed under Alternative 2A would operate from May through September. The gates would be open at tide elevations between 0.0 feet msl and about 3 feet msl, an increase in the tidal period currently allowed by the temporary barriers. Total tidal volume would approach 80% of the tidal volume without gates in place. Operable gates would have a beneficial impact on movement of adult and juvenile Chinook salmon because of the potential management flexibility and increased period of access to Middle River, Grant Line Canal, and Old River (i.e., passage conditions are provided at water surface elevations exceeding 0 feet msl under Alternatives 2A–2C versus passage provided at elevations exceeding 1 foot msl under Alternative 1). The increased flexibility of an operable gate is a beneficial impact.

Impact Fish-7: Effects of Head of Old River Gate Operation on Juvenile Chinook Salmon Entrainment. Closure of the head of Old River fish control gate during April 15 through– May 15, and possibly longer, under Alternative 2A would direct juvenile Chinook salmon down the San Joaquin River during most of the peak out-migration period. Installation of the temporary barrier reduces the number of juvenile Chinook salmon salvaged compared to years when the temporary barrier was not installed (San Joaquin River Group Authority 2003). Although the difference in the estimated survival with and without the gate is not statistically significant, relative survival for juvenile

Impact Fish-11: Construction-Related Loss of Steelhead to Direct Injury. Construction of the gates would include placement of sheetpiles and riprap and could directly injure fish present during the time of construction. Dredging could entrain and injure juvenile steelhead. Cofferdams, if used, would be installed to isolate gate construction areas from the channel. Placement of cofferdams in the channels could trap juvenile steelhead. Fish that become trapped inside the cofferdams could be killed during desiccation of the construction area and other construction activities. Direct injury associated with construction and maintenance activities, including dredging, would have a less-than-significant impact on steelhead because the number of fish injured is likely small given that:

- in-water construction, including the construction of a cofferdam, would occur between August and November;
- the area of construction activity is small relative to the channel area providing passage through the south Delta;
- in-water construction and dredging would occur over a relatively short period (i.e., about 3 years); and
- most juvenile and adult steelhead would move away from construction activities and into adjacent habitat of similar quality.

No mitigation is required.

Impact Fish-12: Construction-Related Loss of Steelhead to Predation. Construction of gates and extension of agricultural intakes would add permanent structure and cover to the south Delta channels. The addition of structure has the potential to increase the density of predator species and predation on fish moving around and past the structure. Similar to Chinook salmon, predation associated with the addition of the operable gates and the agricultural intake extensions to the south Delta channels could cause a small and likely negligible (i.e., less-than-significant impact) increase in mortality of the juvenile steelhead moving past the structures. The determination is based on the same factors described for juvenile Chinook salmon (Impact Fish-7). No mitigation is required.

Impact Fish-13: Effects of Head of Old River Gate Operation on Juvenile ~~Steelhead Migration~~and Adult Steelhead Migration.~~,~~ Closure of the head of Old River fish control gate would minimize the movement of juvenile steelhead into Old River after April 15 (and possibly earlier), the same as for Chinook salmon juveniles (See Impact Fish-6). Most juvenile steelhead are salvaged between January and April at the state water facilities so entrainment can still occur before April 15. Although the effects of gate closure are similar for both Alternatives 1 and 2A, an operable gate constructed under Alternative 2A would provide increased opportunities for fish protection in response to new information on fish survival for variable flows and migration pathways. The increased flexibility is a beneficial impact.

Chinook salmon (Impact Fish-5), the addition of structure has the potential to increase the density of predator species and predation on fish moving around and past the structure. Concentrations of disoriented fish increase prey availability and create predator habitat.

Predation associated with the addition of the operable gates and the agricultural intake extensions to the south Delta channels could cause a small and likely negligible (i.e., less-than-significant impact) increase in mortality of the delta smelt moving past the structures. The determination is based on several factors. Design elements will minimize turbulence that could disorient fish and increase vulnerability to predation. The structures would not create conditions that could concentrate delta smelt. Flow velocity would be similar to velocities within the channel upstream and downstream of the gates and the agricultural intake extensions.

The transition zones between various elements of the gates (e.g., sheetpiles and riprap) could provide low-velocity holding areas for predatory fish. Predatory fish holding near the gates and agricultural intakes could prey on vulnerable species. The additional predator habitat created by the gates and intake extensions would have a less-than-significant impact on delta smelt because the increase in potential predator habitat is small relative to habitat in adjacent areas, including the habitat currently created by the temporary barriers and habitat at the existing agricultural intakes. Disorientation and concentration of juvenile and adult fish would be minimal given the size and design of the gates. No mitigation is required.

Impact Fish-20: Effects of Gate Operation on Delta Smelt Spawning and Rearing Habitat, and Entrainment. Under constant SWP and CVP pumping, gate closure causes additional net flow to be drawn from the San Joaquin River and south through Old River, Middle River, and Turner Cut (Section 5.2, Delta Tidal Hydraulics). The increased net flow toward the south may increase entrainment of larval and juvenile delta smelt (see the following section on Entrainment). The effects of gate closure are similar for Alternatives 1 and 2A, however the fish control gate constructed under Alternative 2A c~~w~~ould be operated for all of April and May. The GORT will use real time data to determine the best way to operate the gate before and after the April 15 through May 15 (VAMP) period.

Flow control gates in Middle River, Grant Line Canal, and Old River at DMC could affect access to spawning and rearing habitat for delta smelt in the south Delta channels. The gates constructed under Alternative 2A would be open at tide elevations between 0.0 feet msl and about 3 feet msl, an increase in the tidal range currently allowed by the temporary barriers. Total tidal volume would approach 80% of the tidal volume that would occur without gates in place. The flow control gates could have a beneficial impact on movement of delta smelt by enhancing access to Middle River, Grant Line Canal, and Old River. Measurable benefits to delta smelt, however, are likely small considering the assumed high probability that larval and juvenile delta smelt spawned in the south Delta would be entrained in diversions (see the following section on Entrainment).

construction and maintenance activities, including dredging, would have a less-than-significant impact on green sturgeon. This determination is based on the fact that:

- the area of construction activity is small relative to the channel area providing similar habitat quality in the south Delta;
- in-water construction and dredging would occur over a relatively short period (i.e., about 3 years) and be limited to the August to November timeframe; and
- most juvenile and adult green sturgeon would move away from construction activities and into adjacent habitat of similar quality.

No mitigation is required.

Impact Fish-40: Construction-Related Loss of Green Sturgeon to Predation. Increased predation could be associated with the addition of the operable gates and the agricultural intake extensions to the south Delta channels. Design elements, however, will minimize turbulence that could disorient fish and increase vulnerability to predation. The structures would not create conditions that could concentrate green sturgeon. The increase in potential predator habitat is small relative to habitat in adjacent areas, including the habitat currently created by the temporary barriers and habitat at the existing agricultural diversion intakes. Disorientation and concentration of juvenile fish would be minimal given the size and design of the gates. This impact is less than significant. No mitigation is required.

Impact Fish-41: Effects of Gate Operation on Green Sturgeon Migration. The head of Old River fish control gate w~~e~~ould be closed from April 15 through May 15~~4 to June 1~~ under both Alternatives 1 and 2A. Under Alternative 1, a temporary fixed barrier is constructed each year. Under Alternative 2A, an operable gate would be constructed with bottom-hinged gates that would allow a range of operations, including extension of the closure from April 1 through June 1, depending on decisions made by the GORT. Currently, there is no available data about the migratory paths of adult or juvenile green sturgeon. If green sturgeon migrate through the South Delta, the gate closure could minimize the movement of green sturgeon into the Sacramento River and out to the Pacific ocean. The effects of gate closure on sturgeon that may use the South Delta as a migratory path are unknown. However, closure of the Old River fish control gate would not preclude juvenile and adult sturgeon movement between the San Joaquin River upstream of Old River and the Sacramento River or Pacific Ocean. Closure of the head of Old River fish control gate increases the San Joaquin River flow past Stockton and green sturgeon that may migrate through the South Delta would presumably use the route past Stockton to migrate into the Saramento River and out to the Pacific Ocean. This impact is less than significant. No mitigation is required. Other gate operations would have the same effect on sturgeon.

mitigation measure ensures that impacts on fall-run Chinook salmon from the San Joaquin River would be less than significant.

SWP pumping capacity in excess of 6,680 cfs will not be allowed from May 16 through May 31 if EWA actions are taken to reduce entrainment. The reduction in allowable SWP pumping above 6,680 cfs provided by DWR as mitigation will not exceed the reduction in pumping for fish protection provided by EWA. The reduction from 8,500 cfs to 6,680 cfs will not be charged to the EWA as long as the EWA action reduces export pumping by at least 1,820 cfs.

Substantial uncertainty surrounds the assessment and the significance determination for entrainment-related impacts on fall-run Chinook salmon from the San Joaquin River. Uncertainty is associated with the following assessment assumptions:

- Entrainment-related loss increases linearly with increased SWP and CVP pumping. (Alternative assumptions: Entrainment-related loss is asymptotic, and increased SWP pumping beyond the asymptote results in minimal additional loss, or entrainment losses increase at higher pumping.)
- Most of the entrainment-related losses attributable to the SWP pumping are related to predation on juvenile Chinook salmon in CCF. (Alternative assumptions: Predation in CCF is not a major contributor to entrainment-related losses; and the level of predation in CCF is similar to predation in Delta channels.)
- Although the head of Old River fish control gate prevents fish from moving into Old River and increases survival, additional net movement of San Joaquin River flow into Turner Cut in response to increased SWP pumping increases entrainment-related mortality of juvenile Chinook salmon. (Alternative assumption: Net channel flow in Turner Cut, Old River, and Middle River does not affect survival of juvenile Chinook salmon in the San Joaquin River channel downstream of Stockton.)
- Entrainment-related mortality, including predation at the SWP and CVP pumping facilities, losses through the fish protection facilities, trucking and handling losses, and mortality attributable to SWP and CVP operations effects on channel flow conditions in the Delta, is sufficient to reduce juvenile abundance to a level that would affect population resilience and persistence. (Alternative assumption: Entrainment-related mortality and subsequent reduction in juvenile abundance would not affect population resilience and persistence.)

To help address these uncertainties, DWR and Reclamation will continue to support IEP and ~~CALFED Science Program initiatives~~related CALFED Program activities to better understand and quantify the actual entrainment-related losses at the CVP and SWP salvage facilities, and the efficacy of the head of Old River fish-control gate. This mitigation measure could be modified, as described under the adaptive management framework that is summarized at the end of the impact assessment section. This mitigation measure may be replaced by the long-term

Mitigation Measure Fish-MM-2: Minimize Entrainment-Related Losses of Juvenile Winter- and Spring-Run Chinook Salmon That May Be Caused by Increased SWP Pumping from March 1 through April 14 and May 16 through May 31. The significant impact of increased entrainment-related mortality of juvenile winter- and spring-run Chinook salmon is attributable to a simulated increase in SWP pumping during March (winter run) and April–May (spring run). This mitigation measure ensures that impacts on winter- and spring-run Chinook salmon would be less than significant and includes the following components that build upon and integrate with Mitigation Measure Fish-MM-1:

SWP pumping capacity in excess of 6,680 cfs will not be allowed from March 1 through April 14 if EWA actions are taken to reduce entrainment. The reduction in allowable SWP pumping above 6,680 cfs provided by DWR as mitigation will not exceed the reduction in pumping for fish protection provided by EWA. The reduction from 8,500 cfs to 6,680 cfs will not be charged to the EWA as long as the EWA action reduces pumping by at least 1,820 cfs.

DWR and Reclamation will continue to support IEP ~~and CALFED Science Program initiatives~~and related CALFED Program activities to better understand and quantify the actual entrainment-related losses at the CVP and SWP salvage facilities, and the efficacy of the DCC closure that is assumed to protect these Sacramento River fish. This mitigation measure could be modified, as described under the adaptive management framework that is summarized at the beginning of the impact assessment section above. This mitigation measure may be replaced by the long-term EWA if it is sufficient to operate from the Stage 2 permited SWP pumping basline.

Impact Fish-48: Operations-Related Reduction in Food Availability for Chinook Salmon. Many of the same factors affecting rearing habitat area would be expected to affect food production and availability for juvenile Chinook salmon. Changes in water supply operations potentially affect prey habitat in the Sacramento, Feather, and American Rivers. The flow simulated for 1922–1994 in the Sacramento, Feather, and American Rivers for Alternative 2A varies relative to flow under Alternative 1 (Figure 6.1-5). The reduction in flow in some months and increases for other months and years has minimal effect on the range of flows that could affect rearing habitat area for juvenile Chinook salmon (Table 6.1-14) and would likely have minimal effect on habitat supporting prey organisms. The impact on food for Chinook salmon would be less than significant.

Inundated floodplain in the Yolo and Sutter Bypasses provides important access by fish to prey organisms and input of nutrients to the rivers and Delta (Sommer and Harrell et al. 2001). As previously discussed for juvenile Chinook salmon rearing habitat, the frequency of floodplain inundation in the Yolo and Sutter Bypasses was estimated under Alternative 1 for the 1922–1994 water years (Figure 6.1-10). Most flooding occurs from December though April, coinciding with downstream movement and rearing by juvenile Chinook salmon in all runs (Table 6.1-2). Changes in water supply operations under Alternative 2A could reduce flooding in November of one year for the Sutter Bypass and in December

Impact Fish-52: Operations-Related Reduction in Survival of Coho Salmon in Response to Changes in Water Temperature in the Trinity River. Simulated water temperature for the Trinity River is nearly the same for Alternative 1 and Alternative 2A (Figure 6.1-14), although warmer and cooler water temperatures occur in some months. (Note: Points that fall off of the 45° line in the figures for water temperature indicate warming [above the line] or cooling [below the line] relative to the No Action Alternative.) As indicated previously, changes in Trinity River flow are minimal and would not affect water temperature. The simulated changes in water temperature under Alternative 2A are caused by simulated changes in export of Trinity River water to the Sacramento River (Figure 6.1-15). Although the annual water volume exported to the Sacramento River is nearly the same under Alternative 1 and Alternative 2A, the monthly volume of Trinity River exports under Alternative 2A varies from the volume exported under Alternative 1.

Water exported to the Sacramento River is released from Trinity Reservoir to Lewiston Reservoir. Water in Lewiston Reservoir is either released to the Trinity River or exported to the Sacramento River. When Trinity Reservoir releases are low during warmer months, water traversing Lewiston Reservoir warms considerably prior to release to the Trinity River. Under Alternative 2A, the warming of water temperature in some months coincides with reduced export of Trinity River water and the cooling coincides with increased export.

~~Increased water temperature in the Trinity River during the fall months could have an adverse effect on coho salmon and other salmonids.~~ Survival indices were assigned to the water temperature simulated for each month of occurrence for adult migration, spawning, juvenile rearing, and smolt migration life stages of coho salmon in the Trinity River. Water temperature conditions under Alternative 1 are optimal (an index of 1) for most months (Table 6.1-25). For all life stages, the water temperature survival indices are nearly the same for Alternatives 1 and 2A (Table 6.1-26). The frequency of change in indices for adult migration show the most change, but only 8 months out of 288 simulated months of migration are affected, and the number of declines in the survival indices is similar to the number of increases. The shift in water temperature survival indices would not affect adult migration or other life stages. The change in water supply operations under Alternative 2A would not affect survival of coho salmon in the Trinity River. This potential impact is less than significant. No mitigation is required.

pumping that is above the existing permitted capacity. Under this mitigation component, for each 100 taf of non-EWA pumping above the existing permitted capacity, a pumping reduction credit, ranging from 10 taf to 30 taf, could be used by EWA to reduce pumping during periods of high fish density.

This relatively simple avoidance of impacts during periods of EWA actions, in addition to an EWA credit for mitigation of periods with remaining pumping above the existing permitted capacity, will reduce the delta smelt entrainment impacts to less than significant. DWR and Reclamation will coordinate with DFG, NOAA Fisheries, and USFWS to determine the appropriate credit percentage.

When an expanded EWA (i.e., greater than CALFED ROD EWA) is implemented by CALFED, as assumed in the 2004 OCAP documents, this SDIP mitigation measure would no longer be required because the expanded EWA is assumed to be sufficient to mitigate any entrainment impacts from the incremental pumping above the existing permitted capacity. The SWP has proposed increased funding through an amended Four-Pumps Agreement to support SDIP mitigation measures, including an expanded EWA. In the absence of the EWA, that increased funding would continue to be available to DFG to mitigate impacts of the SDIP through purchases of water to reduce pumping during critical periods for fish or other mitigation strategies developed through the adaptive management process.

DWR and Reclamation will continue to support IEP and related CALFED Program activities ~~CALFED Science Program initiatives~~ to better understand and quantify the actual entrainment-related losses at the CVP and SWP salvage facilities, improved salvage techniques for delta smelt, and the effects of the head of Old River fish control gate on the movement of relatively high densities of delta smelt from the vicinity of Franks Tract. This mitigation measure could be modified, as described under the adaptive management framework that is summarized at the beginning of the impact assessment section above, utilizing in whole or in part, increased funds available through the Four-Pumps Agreement.

Impact Fish-64: Operations-Related Reduction in Food Availability for Delta Smelt. Many of the same factors affecting rearing habitat area would be expected to affect food production and availability for delta smelt. As discussed above for rearing habitat area, changes in water supply operations potentially affect estuarine rearing habitat area for delta smelt in the Delta and Suisun Bay. Location of rearing habitat area downstream of the Delta is believed to increase food availability for delta smelt (U.S. Fish and Wildlife Service 1996). The broad and shallow areas of Suisun Bay allow algae to grow and reproduce rapidly, providing food for zooplankton, which are food for delta smelt. Greater rearing habitat area for delta smelt coincides with location downstream of the Delta and within the areas of higher zooplankton production. The change in estuarine rearing habitat area under Alternative 2A is small (generally less than 5%) and infrequent for most years during all months (Figure 6.1-18). Given the few rearing months affected, especially during April

Stage 2 (Operational Component)

The monthly state and federal operational patterns of Alternative 4B are the same as Alternative 2B (see Alternative 2B in Sections 5.1, Water Supply, and 5.3, Water Quality). Therefore, the operational impacts resulting from state and federal operations under Alternative 4B are the same as described for Alternative 2B.

Thus, operations-related impacts for Alternative 4B on Chinook salmon, steelhead, delta smelt, splittail, striped bass and green sturgeon are the same for operational impacts described for Alternative 2B under 2001 conditions.

2020 Conditions

Water supply for Alternative 4B under 2020 conditions are similar to water supply for 2001 conditions. Streamflows, pumping, and diversions associated with Alternative 4B simulated under 2020 conditions are similar to the 2001 conditions simulation. Therefore, the operations-related impacts for Alternative 4B under 2020 conditions and their levels of significance on Chinook salmon, steelhead, delta smelt, splittail, striped bass and green sturgeon are the same as the impacts described for 2001 conditions, and subsequently, are nearly the same as Alternative 2B under 2001 conditions.

Adaptive Management

To address uncertainties associated with the effectiveness of some of the mitigation measures described for SDIP alternatives, DWR and Reclamation will implement these measures based on the principles of adaptive management, which allow these measures to be adjusted over time, based on results of monitoring and research. The mitigation measures that are subject to adaptive management are related to measures designed to minimize effects on special-status fish species. These species and mitigation measures are shown below:

- Delta smelt—
  - Minimize Entrainment Losses of Juvenile Delta Smelt Associated with Increased SWP Pumping during March–June.
- Central Valley fall-/late fall–run Chinook salmon, Central Valley spring-run Chinook salmon, Sacramento winter-run Chinook salmon, and Central Valley steelhead—
  - Minimize Entrainment-Related Losses of Juvenile Fall-/Late Fall–Run Chinook Salmon Associated with Increased SWP Pumping during March–June.

Results of SDIP effectiveness monitoring and relevant monitoring and research will be conducted consistent with the CALFED Science Program and ~~conducted through the CALFED Science Program~~ will be used to determine the effectiveness of these mitigation measures in minimizing effects on special-status gate operation choices to provide maximum water level, water quality, and fish protection benefits from the flow control gate operations:

1. Operation of the CCF intake gates have two main effects that must be balanced: If the gates are closed during the flood-tide flows prior to the high tide each day, the tidal flushing in south Delta channels can be maximized, and levels at high tide throughout the south Delta channels are preserved. This will allow Tom Paine Slough siphons to operate and provide the maximum tidal flushing upstream of the flow control gates. Fish migration patterns for Chinook salmon or delta smelt might be triggered or cued to tidal fluctuations or diurnal periods (i.e., dawn and dusk). As more is learned about these diurnal or tidal migration patterns, the CCF gate schedule might be modified to reduce opening at peak fish density periods within the day. The CCF intake gates, however, must be opened for a sufficient period each day to maintain the CCF elevations above -2.0 feet msl to prevent cavitation problems at SWP Banks, which is often used for maximum off-peak (nighttime) pumping.

2. The head of Old River fish control gate can be operated to reduce the San Joaquin River diversions into Old River. This will increase the San Joaquin River flow past Stockton and improve DO conditions in the DWSC, which is assumed to provide fish habitat benefits. Reduction of the head of Old River diversions will also reduce the inflow of higher-salinity San Joaquin River water into the south Delta channels. This may also be beneficial for adult up-migrating Chinook salmon past Stockton during the months of September through November. However, reduced diversions will cause more water to be drawn from the central Delta to supply the CVP and SWP pumping, which may increase entrainment of some larval or juvenile fish (e.g., delta smelt) from the central Delta. Partial closure of the head of Old River gate will also shift the distribution of San Joaquin River salinity away from the CVP Tracy facility toward the CCWD intakes and the SWP Banks facility. There do not appear to be any substantial effects on water levels in the south Delta channels from reduced San Joaquin River diversions at the head of Old River if flow control gates are being operated. Closure of the fish control gate for fish protection or DO improvement may be possible for more of the time than was simulated in the DSM2 modeling of the SDIP alternatives~~.~~, or for less of the time than was simulated if other fish concerns appear to be more important. The GORT will direct these gate operation decisions, considering real-time data and the range of possible benefits and impacts. ~~The fish control gate operations must satisfy the SDIP objective to protect outmigrating Chinook salmon juvenile smolts, as well as satisfy HY-MM-2, WQ-MM-2, WQ-MM-3, and WQ-MM-4.~~

3. The flow control gates at Grant Line Canal, Old River at DMC, and Middle River can be used to control the water levels in the south Delta channels. In addition, ebb-tide closure of the Old River and Middle River flow control gates can produce a net circulation upstream on Old River and Middle River and downstream in Grant Line Canal. The simulation of the ~~This~~ ebb-tide closure of Old and Middle River flow control gates ~~was simulated~~indicated~~is expected~~that there would be ~~to have~~ a beneficial effect on salinity in these south Delta channels. ~~and should be considered for Alternatives 2A, 2B, and~~

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2C, although only required as mitigation for Alternative 3B. The ebb-tide closure of the flow control gates is not anticipated to substantially change interrupt the fish movement patterns that are may be triggered by or associated with tidal flows. The GORT will direct these gate operation decisions, considering real-time data and the range of possible benefits and impacts.

Mitigation Measures HY-MM-1, HY-MM-2, and HY-MM-3, as well as WQ-MM-1, WQ-MM-2, WQ-MM-3, and WQ-MM-4, involve operations of the CCF gates, the head of Old River fish control gate, and the Old River and Middle River flow control gates to provide more suitable tidal hydraulic and water quality conditions in the south Delta channels, and provide protection for migrating fish in the San Joaquin River. These mitigation measures will vary on a day-by-day basis depending on the inflows, export pumping, and water quality conditions measured at Vernalis and within the south Delta, as well as fish densities measured at the CVP and SWP salvage facilities and in the Mossdale trawls. Each of these mitigation measures therefore should be implemented using these recommended adaptive management procedures for operating the south Delta flow control gates.

Table 6.1-2. Assumed Life Stage Timing and Distribution of Selected Species Potentially Affected by the Proposed SDIP Alternatives

	Distribution	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Late Fall–Run Chinook Salmon													
Adult Migration	SF Bay to Upper Sac River and Tributaries, Mokelumne River~~, and SJR Tributaries~~												
Spawning	Upper Sacramento River and Tributaries, Mokelumne River~~, and SJR Tributaries~~												
Egg Incubation	Upper Sacramento River and Tributaries, Mokelumne River~~, and SJR Tributaries~~												
Juvenile Rearing (Natal Stream)	Upper Sacramento River and Tributaries, Mokelumne River~~, and SJR Tributaries~~												
Juvenile Movement and Rearing	Upper Sacramento River and Tributaries, Mokelumne River~~, and SJR Tributaries~~												
Fall-Run Chinook Salmon													
Adult Migration and Holding	SF Bay to Upper Sacramento River and Tributaries and SJR Tributaries[1]												
Spawning[2]	Upper Sacramento River and Tributaries and SJR Tributaries[1]												
Egg Incubation[2]	Upper Sacramento River and Tributaries and SJR Tributaries[1]												
Juvenile Rearing (Natal Stream)	Upper Sacramento River and Tributaries and SJR Tributaries[1]												
Juvenile Movement	Upper Sacramento River and Tributaries to SF Bay and SJR Tributaries[1]												
Spring-Run Chinook Salmon													
Adult Migration and Holding	SF Bay to Upper Sacramento River and Tributaries												
Spawning	Upper Sacramento River and Tributaries												
Egg Incubation	Upper Sacramento River and Tributaries												
Juvenile Rearing (Natal Stream)	Upper Sacramento River and Tributaries												

Table 6.1-2. Continued

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	Distribution	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Juvenile Movement	Upper Sacramento River and Tributaries to SF Bay												
Winter-Run Chinook Salmon													
Adult Migration and Holding	SF Bay to Upper Sacramento River												
Spawning	Upper Sacramento River												
Egg Incubation	Upper Sacramento River												
Juvenile Rearing (Natal Stream)	Upper Sacramento River to SF Bay												
Juvenile Movement and Rearing	Upper Sacramento River to SF Bay												
Steelhead													
Adult Migration	SF Bay to Upper Sacramento River and Tributaries and SJR Tributaries												
Spawning	Upper Sacramento River and Tributaries and SJR Tributaries												
Egg Incubation	Upper Sacramento River and Tributaries and SJR Tributaries[1]												
Juvenile Rearing	Upper Sacramento River and Tributaries to SF Bay and SJR Tributaries												
Juvenile Movement	Upper Sacramento River and Tributaries to SF Bay and SJR Tributaries												
Southern Oregon/Northern California Coasts Coho Salmon													
Adult Migration	Trinity River												
Juvenile Rearing	Trinity River												
Juvenile Movement	Trinity River												

Table 6.1-2. Continued

	Distribution	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Splittail													
Adult Migration	Suisun Marsh, Upper Delta, Yolo and Sutter Bypasses, Sacramento River and SJR												
Spawning	Suisun Marsh, Upper Delta, Yolo and Sutter Bypasses, Lower Sacramento and SJ Rivers												
Larval and Early Juvenile Rearing and Movement	Suisun Marsh, Upper Delta, Yolo Bypass, Sutter Bypass, Lower Sacramento and San Joaquin Rivers												
Adult and Juvenile Rearing	Delta, Suisun Bay												
Delta Smelt													
Adult Migration	Delta												
Spawning	Delta, Suisun Marsh												
Larval and Early Juvenile Rearing	Delta, Suisun Marsh												
Estuarine Rearing: Juveniles and Adults	Lower Delta, Suisun Bay												

Notes:

SF Bay = San Francisco Bay.

SJR = San Joaquin River.

[1] Boxes with hash marks denote timing for the San Joaquin River and the Sacramento River.

[2] Spawning and incubation occurs from October to February in the Feather, American, and Mokelumne Rivers

Sources: Brown 1991; Wang and Brown 1993; U.S. Fish and Wildlife Service 1996; McEwan 2001; Moyle 2002; Hallock 1989; Baker and Morhardt 2001; Foss 2004.

Table 6.1-12. Continued

Project Actions	Impact Mechanisms Associated with Implementing Project Actions	Affected Environmental Conditions
Operate gates on Middle River, Grant Line Canal, and Old River and a fish control structure at the head of Old River	Operate the gates (i.e., Middle River, Grant Line Canal, and Old River) to maintain a minimum level above 0.0 feet mean sea level during May through September. Operate the head of Old River gate to minimize movement of juvenile fall-run Chinook salmon from the San Joaquin River into Old River from April 1 to May 31., or as recommended by USFWS, NOAA Fisheries, and DFG. Operate the head of Old River gate to increase flow in the San Joaquin River past Stockton during September 15–November 30.	Gate: the closure of the bottom-hinged gates at the head of Old River will block flow and fish movement; closure of the bottom-hinged gates at other gates will block flow and fish movement during levels less than 0.0 feet mean sea level. Level: operation of the gate will maintain level at 0.0 feet mean sea level in the channels on the upstream side of the gates and potentially reduce inter-tidal area. Flow velocity: operation of the gate will affect circulation in the channels on the upstream and downstream side of the gates. Net flow direction: depending on interaction between inflow and diversions, net flow direction may change in some channels. Soil moisture: higher level could increase soil moisture elevation on lands adjacent to the affected channels. Cover: change in level could affect maintenance and establishment of riparian and aquatic vegetation, affecting the availability of cover. Contaminants: change circulation may change residence time and volume and the concentration of salts, pesticides, nutrients, and other materials from agricultural return flows. Water temperature: change in circulation could change water temperature. Dissolved oxygen: change in circulation could change dissolved oxygen levels. Predator effectiveness: the operation of the gates could potentially create feeding areas for predator species and hydraulic conditions that disorient prey. Non-native predator species: change in cover, depth, and velocity may alter habitat to favor non-native species in the channels between gates. Food: change in residence time, in combination with change in contaminants, may affect food production.