3.4.3 Other Stressors Conservation Measures

3.4.3.1 Introduction

This section describes BDCP conservation measures that address stressors to covered fish species that are not directly related to water operations and physical habitat restoration, collectively titled "Other Stressors." Other stressors conservation measures address toxic contaminants, other water quality issues (e.g., dissolved oxygen), non-native species, hatcheries, harvest, and non-project diversions.

Many of these conservation measures address issues and activities that are not currently within the direct control of the BDCP Implementing Entity. The other stressors conservation measures that will be implemented through agreements with third parties are framed to establish reliable mechanisms to promote their execution and success by those parties.

In instances where a third party is proposed to implement the conservation measure funded by the BDCP, the BDCP Implementing Entity would enter into Memoranda of Agreement (MOA) or similar binding instruments with the third party. These MOAs would generally describe respective roles and obligations for funding and implementing conservation measures as identified through the process described above. Specific elements of the MOA would include:

- a description of specific activities that would be funded by BDCP;
- a description of BDCP funded equipment purchases and capitol improvements;
- preparation of annual research work plans for BDCP funded activities;
- provisions for documenting work performed; and
- provisions for modifying or terminating MOAs.

The third party, in coordination with the BDCP Implementing Entity and the Fishery Agencies, will develop annual work plans that describe activities or capitol improvements that would be funded by BDCP. The third party would be responsible for implementing the scope of work and submitting reports as specified in the MOA that demonstrate that work plans have been successfully implemented. The third party would be responsible for demonstrating the effectiveness of the funded activities to meet objectives as specified in the MOA.

The BDCP Implementing Entity in coordination with the Fishery Agencies would review progress or other relevant reports prepared by the third party to assess program effectiveness and to identify adjustments to funding levels, management practices, or other related aspects of the program that would improve the biological effectiveness of the program. Such changes would be effected through the BDCP adaptive management process and would be included in the subsequent annual work plans.

If program assessments indicate that a particular conservation measure is not effective in achieving stated objectives, the BDCP Implementing Entity, in coordination with Fishery Agencies, may terminate the conservation measure. A conservation measure would also be terminated if participation of a third party is required for its implementation and that party declines to enter into an agreement with the BDCP Implementing Entity. If terminated, remaining funding would be deobligated from the conservation measure and reallocated to augment funding for other more effective conservation measures identified in coordination with the Fishery Agencies through the BDCP adaptive management process (see Section 3.7, *Adaptive Management*).

- For conservation measures with MOAs that would be different from this approach, a brief description of those differences is provided in the description of those conservation measures.

OSCM3: Reduce the Load of Methylmercury Entering Delta Waterways. *[**Note to reviewers**: SAIC is in discussion with CVRWQCB and DWR regarding the logistics and feasibility of this measure. More detail will be added as it becomes available]* The BDCP Implementing Entity will provide $____ over the term of the BDCP to DWR and the Central Valley Regional Water Quality Control Board (CVRWQCB) to reduce the load of methylmercury entering the Delta and in-Delta sources in conformance with CVRWQCB's Draft Total Maximum Daily Load (TMDL)[1] . Funding provided under this conservation measure could support staff salaries and/or fund specific actions to reduce these sources (e.g., Cache Creek Settling Basin efficiency improvements). Example actions that would be supported include:

1. work with DWR and CVRWQCB to expand the areal extent of the Cache Creek settling basin and raise the existing weir to improve mercury and sediment trapping efficiency (estimated construction cost of $17.6 million), and annually extract 500,000 cubic yards of accumulated sediment to extend the working life of the Cache Creek settling basin (estimated annual cost of $3-6 million). The Cache Creek drainage basin is a small portion (~4%) of the area drained by the Sacramento River, but can contribute up to 50% of the total annual mercury load of the Sacramento River (Foe and Croyle 1999 in Domagalski et al. 2004);
2. remediate inorganic mercury sources upstream of the Delta, particularly mercury and gold mines;
3. work with CVRWQCB to identify and implement most promising management practices for other sources of methylmercury.

In addition, the BDCP Implementing Entity will minimize to the extent practicable any increase in mercury methylation associated with habitat restoration conservation measures through the design and implementation of restoration projects (see Section 3.4.2).

The BDCP Implementing Entity will enter into a Memorandum of Agreement (MOA) or similar binding instrument with DWR, CVRWQCB and/or other third parties as described under Section 3.4.3.1.

Problem statement: It has been demonstrated that higher concentrations of methylmercury in waterways lead to higher concentrations of this neurotoxin in wildlife species (references). There have not been direct studies on mercury's effects of BDCP covered species' survival and fecundity in the Delta, although results of studies conducted on related species (e.g., Atlantic salmon) suggest that mercury is an environmental stressor that should be addressed by the BDCP.

Studies on similar species have shown numerous negative effects on fish and terrestrial wildlife reproductive success, fledgling success, and predator avoidance (references). Methylmercury, the bioavailable form of mercury, bioaccumulates within an individual and biomagnifies up the food

[1] The Central Valley Regional Water Quality Control Board has released a Draft Sacramento-San Joaquin Delta TMDL for Methylmercury (CVRWQCB 2008). The Draft TMDL calls for a 50% reduction of methylmercury entering the Delta, sources of which include tributaries from upstream watersheds and within-Delta sources, municipal and industrial wastewater, agricultural drainage, and urban runoff. The largest sources of methylmercury to the Delta are flux from wetland and open water sediments within the Delta and Yolo Bypass (~35% of total load) and upstream tributaries (~58% of total load). The Draft TMDL recommends total mercury load reductions from the Feather River, Cache Creek, Putah Creek, and American River watersheds.

chain, causing an increase in the manifested effects. Bioaccumulation of mercury in invertebrates (particularly benthic crustaceans) and fish has been observed (references).

There is limited evidence of physical effects of mercury in covered fish species, although physiological damage may still occur. Pacific lamprey ammocoetes can absorb mercury at high rates (Bettaso and Goodman 2008), although effects on the species is unknown. Berntssen et al. (2003) found that Atlantic salmon (*Salmo salar*) exposed to several levels of methylmercury showed no signs of mortality or growth reduction, but had numerous internal effects including a decrease in anti-oxidant enzyme activity, pathological damage (vacuolation and necrosis), significantly reduced neural enzyme activity, and reduced overall post-feeding activity behavior.

Hypotheses: Reducing the load of methylmercury entering Delta waterways is hypothesized to provide benefits to a number of fish species, the Delta ecosystem, and human health. Specifically, this conservation measure is hypothesized to:

- Reduce fish exposure to mercury in Delta waterways. Fish are exposed to mercury primarily through consumption, and secondarily through direct exposure to high concentrations in the water column, although the latter is substantially lower than the former (Alpers et al. 2008);
- Reduce deleterious side effects of dietary mercury on fish in the Delta waterways. Effects of dietary mercury on fish include, but are not limited to, endocrine and reproductive problems (Friedman et al. 2002, Hammerschmidt et al. 2002), liver necrosis (de Oliveira Ribeiro et al. 2002), brain lesions (Berntssen et al. 2003), and altered behavior that can increase risk of predation (Webber and Haines 2003);
- Potentially augment reproductive potential of white sturgeon, a covered species. There is little evidence that covered species in the Delta are directly affected by mercury, although there is evidence that reproductive potential in white sturgeon are limited by exposure to methylmercury in the lower Columbia River (Webb et al. 2006a);
- Reduce exposure of BDCP terrestrial covered species to mercury. Deleterious effects on bird species from methylmercury consumption include reproductive impairment and juvenile survival (Ackerman et al. 2008, Heinz 1979, Wolfe et al. 1998). Effects on mammals from methylmercury consumption include anorexia, ataxia, and death (Wren et al. 1987, O'Connor and Nielsen 1981); and
- Reduce human exposure to mercury. Another major concern of mercury involves human health. Effects on humans from methylmercury consumption include loss of coordination, slurred speech, and mental disturbances (Bakir et al. 1973, Marsh 1987). Methylmercury toxicity in developing human fetuses can result in cerebral palsy and/or mental retardation (Harada 1978, Marsh et al. 1980 and 1987, Matsumoto et al. 1964, Snyder 1971). Mercury effects have been demonstrated in other species that reside in the Delta, such as fathead minnows and black basses. The Office of Environmental Health Hazard Assessment has published health advisories urging limited human consumption of black basses for multiple waterways in the Delta (see http://www.oehha.ca.gov/).

Adaptive management considerations: The BDCP Implementing Entity will coordinate with the CVRWQCB to adjust mercury reduction strategies and funding levels through the BDCP adaptive management decision making process as appropriate based on results of effectiveness monitoring and review of CVRWQCB monitoring and other relevant reports. The BDCP Implementing Entity would use results of effectiveness monitoring to determine whether reducing mercury loads results in measurable benefits to covered fish species and to identify adjustments to

funding levels, control methods, or other related aspects of the program that would improve the biological effectiveness of the program. Such changes would be effected through the BDCP adaptive management process and would be included in the subsequent annual work plans.

If results of monitoring indicate that reducing mercury loads does not substantially benefit covered fish species, the BDCP Implementing Entity in coordination with Fishery Agencies may terminate this conservation measure. If terminated, remaining funding would be deobligated from this conservation measure and reallocated to augment funding for other more effective conservation measures identified in coordination with the Fishery Agencies through the BDCP adaptive management process. If results of monitoring indicate that BDCP habitat restoration activities increase loads of mercury and/or methylmercury in the Delta, this conservation measure will not be terminated and may be amended to include additional activities to mitigate any increase in loads of mercury and/or methylmercury attributable to restoration of BDCP habitats.

OSCM4: Reduce the Load of Pesticides and Herbicides Entering Delta Waterways from In-Delta Sources that are Believed to be Toxic to Covered Fish Species. The BDCP Implementing Entity will reduce the load of pesticides and herbicides entering Delta waterways from in-Delta sources by implementing two related actions: (1) support efforts by the Central Valley Regional Water Quality Control Board (CVRWQCB) under its Irrigated Lands Regulatory Program to reduce inputs of toxics from agricultural return flows into the Delta and tributaries, and (2) fund conservation easements, cost-sharing programs, and provide incentives to groups of farmers, large individual farmers, reclamation districts, and irrigation/drainage districts to develop voluntary agricultural chemical management plans to reduce the amounts of pesticides and herbicides reaching Delta waterways.

Action 1: The BDCP Implementing Entity will support efforts by the Central Valley Regional Water Quality Control Board (CVRWQCB) under its Irrigated Lands Regulatory Program to reduce inputs of toxics from agricultural return flows into the Delta and tributaries to levels at which they are not toxic to covered fish species by 20__ at a funding level of $___ over the term of the BDCP. The Irrigated Lands Regulatory Program provides dischargers of irrigation water and storm water from irrigated lands with the ability to obtain a waiver to discharge, but under current regulations waivers must be conditional, enforceable, and include monitoring to ensure compliance with these conditions. Dischargers must either join an established coalition group or proceed as an individual discharger. Coalition groups collect fees to monitor and report water quality in discharges. This conservation measure would support and coordinate existing efforts of the Irrigated Lands Regulatory Program in the form of technical assistance, monetary and/or staff support, and encouragement of voluntary actions.

Action 2: The BDCP Implementing Entity will fund conservation easements, cost-sharing programs, and provide incentives to groups of farmers, large individual farmers, reclamation districts, and irrigation/drainage districts to develop voluntary agricultural chemical management actions at a funding level of $__ over the term of the BDCP to reduce the amounts of pesticides and herbicides reaching Delta waterways. It is anticipated that this funding level would reduce inputs of toxics in discharged water from ___ acres of farmland. Funded actions could include:

- Changing pesticides and herbicides used to less toxic compounds to aquatic species and provide education on proper use;
- Reducing amounts of pesticides and herbicides used through more direct application methods such as ground-based target-sensing spray systems, or implementation of integrated pest management techniques;

- Reducing concentrations of pesticides and herbicides in return flows to Delta waterways through specific management practices such as development of vegetation buffer zones between agricultural fields and waterways;
- Minimizing environmental and human health risks by employing integrated pest management techniques;
- Reducing return flows from agricultural fields to the Delta by using water-efficient technologies (e.g., drip irrigation) (K. Fisher pers. comm.);and
- Reducing wind drift of pesticides and herbicides into Delta waterways.

To accomplish Action 1, the BDCP Implementing Entity will enter into a Memorandum of Agreement (MOA) or similar binding instrument with the CVRWQCB as described in Section 3.4.3.1. The BDCP Implementing Entity will be responsible for monitoring the effectiveness of agricultural contaminant reduction activities in achieving covered fish species benefits. This monitoring will be required because of the uncertainties surrounding the population level benefits of reducing loads of agricultural pesticides and herbicides on covered fish species. If the Irrigated Lands Regulatory Program were to be revised in the future by CVRWQCB in such a way that the BDCP Implementing Entity finds that BDCP goals cannot be met, the BDCP would withdraw financial support.

To accomplish Action 2, the BDCP Implementing Entity will enter into binding agreements (e.g., conservation easements, contracts) with participating farmers, irrigation districts, and coalitions that specify specific actions that will need to be implemented by participants to receive BDCP funding. The BDCP Implementing Entity will coordinate with the Fishery Agencies, the CVRWQCB, and the Department of Pesticide Regulation to identify specific pesticides and herbicides to be targeted for reduction and a menu of the types of measures that could be implemented that would cost-effectively reduce loads of targeted compounds. Elements of participant agreements will include:

- a description of specific BDCP funded activities to be implemented by participants;
- provisions for documenting compliance with the agreements;
- access to conduct BDCP effectiveness monitoring; and
- provisions for modifying or terminating participant agreements.

The BDCP Implementing Entity, in coordination with the Fishery Agencies and the CVRWQCB, will develop a pesticide and herbicide reduction monitoring program to assess the effectiveness of funded activities for reducing pesticide and herbicide loads in Delta waterways and providing benefits for covered fish species.

Problem statement: Agricultural runoff has been identified as a source of pesticides and other chemical stressors of covered fish species that adversely effect aquatic biota (Werner et al. 2008, Werner and Oram 2008). Pyrethroid pesticides are particularly toxic to the aquatic environment (Werner and Oram 2008). The use of pyrethroid pesticides has increased steadily since the use of organophosphates was phased out by the US EPA. In addition, metals such as copper are used as pesticides in the Delta. Pesticides have known lethal and sublethal effects on fish species and direct impacts on invertebrates (Van Wijngaarden et al. 2005), which could serve as prey species for covered fish species.

Hypotheses: Reducing the load of pesticides and herbicides entering Delta waterways is hypothesized to provide benefits to covered fish species through the following mechanisms.

1. Reducing direct mortality of splittail, delta and longfin smelt, green and white sturgeon, steelhead, and Chinook salmon (all races) from pesticides. A 2008 NMFS biological opinion concerning pesticides indicated that re-registration of pesticides containing chlorpyrifos, diazinon, and malathion is likely to jeopardize the continued existence of winter-run and spring-run Chinook salmon and Central Valley steelhead (NMFS 2008). Saiki et al. (1992) found that undiluted agricultural drainwater from the San Joaquin River watershed was acutely toxic to juvenile Chinook salmon.

2. Reducing sublethal effects (behavior, tissue/organ damage, reproduction, growth, and immune) of pesticides on splittail, delta and longfin smelt, green and white sturgeon, steelhead, and Chinook salmon (all races). Zelikoff et al. (1998) found that exposure to the pyrethroid permethrin reduced disease resistance in fish. The susceptibility of juvenile Chinook salmon and rainbow trout to infectious hematopoietic necrosis virus was dramatically increased when exposed to sublethal concentrations of copper (Hetrick et al. 1979) and esfenvalerate (Clifford et al. 2005). Dinoseb, diazinon, and esfenvalerate cause significant metabolic disruption in early life stages of Chinook salmon (Viant et al. 2006). Hecht et al (2007) observed that dissolved copper causes a loss of sensory function in Chinook salmon, steelhead, and other salmonids that is thought to cause disruption in migration and predator detection.

3. Increasing food abundance and quality for splittail, delta and longfin smelt, green and white sturgeon, steelhead, and Chinook salmon (all races) by reducing food web disruption. Although pesticides and herbicides are effective at eliminating weeds and pests on agricultural crops, they are also highly toxic to plants and animals in the aquatic environment, particularly to crustaceans, which are closely related to insects (Weston et al. 2005). Amweg et al. (2005) found pyrethroid concentrations at toxic levels to *Hyallela azteca* in many agriculture-dominated waterbodies in the Central Valley. All these covered fish species consume crustaceans (e.g., copepods, amphipods, mysid shrimp) for at least part of their lives. In addition, copper has been shown to reduce algal growth (Stoiber et al. 2007), which could, in turn, limit zooplankton growth.

Adaptive management considerations: For Action 1, the Implementing Entity will coordinate with the CVRWQCB to adjust Irrigated Lands Regulatory Program contaminant reduction strategies and funding levels through the BDCP adaptive management process as appropriate based on results of effectiveness monitoring and review of CVRWQCB monitoring and other relevant reports. The BDCP Implementing Entity would use results of effectiveness monitoring to determine if reducing pesticide and herbicide loads results in measurable benefits to covered fish species and to identify adjustments to funding levels, control methods, or other related aspects of the program that would improve the biological effectiveness of the program. Such changes, once approved through the adaptive management decision making process, will be effected through subsequent annual work plans. If results of monitoring indicate that reducing pesticide and herbicide loads does not substantially and cost-effectively benefit covered fish species, the BDCP Implementing Entity, in coordination with Fishery Agencies, may terminate this conservation measure. If terminated, remaining funding would be deobligated from this conservation measure and reallocated to augment funding for other more effective conservation measures identified in coordination with the Fishery Agencies through the BDCP adaptive management process.

For Action 2, the Implementing Entity will monitor the effectiveness of participating farmers/farmer groups in reducing loads of targeted pesticides and herbicides. Based on monitoring results and ongoing reviews of relevant research related to the effects of pesticides and herbicides on covered fish species and food production and abundance, the Implementing Entity may adjust activities for which cost sharing is provided to participating farmers through the BDCP adaptive management process. For example, if results of future research indicates that specific pesticides and herbicides do not measurably adversely affect covered fish species, funding for programs to reduce loads of those pesticides and herbicides would be discontinued and redirected through the BDCP adaptive management process to increase funding for reduction of pesticides and herbicides that are shown to be harmful to covered fish species.

The BDCP Implementing Entity in coordination with the Fishery Agencies may discontinue effectiveness monitoring for both of the actions in future years if monitoring results indicate a strong correlation between reduction in pesticide and herbicide loads entering the Delta and responses of covered fish species.

OSCM5: Reduce the Loads of Toxic Contaminants in Stormwater and Urban Runoff by Working with Existing Efforts in the Delta. The BDCP Implementing Entity will provide funding to the Sacramento Stormwater Quality Partnership, San Joaquin County, the City of Stockton, and/or other counties and cities whose stormwater contributes to Delta waterways (hereafter "stormwater agencies") under National Pollutant Discharge Elimination System (NPDES) MS4 stormwater permits to implement actions from and in addition to their respective stormwater management plans. Actions in addition to those in existing plans/programs will be implemented if they are expected to benefit covered species.

Actions that could be funded under this measure include:

- construction of retention/irrigation holding ponds for the capture and irrigation use of stormwater;
- design and establishment of vegetated buffer strips to slow runoff velocities and capture sediments and other pollutants;
- design and construction of bioretention systems (grass buffer strips, sand bed, ponding area, mulch layer, planting soil, and plants) to slow runoff velocities and for removal of pollutants from stormwater; and
- establishment of stormwater media filters to remove particulates and pollutants.

The BDCP Implementing Entity will enter into Memoranda of Agreement (MOAs) or similar binding instruments with local agencies responsible for stormwater runoff as described in Section 3.4.3.1. Individual cities will be responsible for conducting the monitoring necessary to assess the effectiveness of BDCP supported elements of their stormwater management plans. The BDCP Implementing Entity, in coordination with the Fishery Agencies, will be responsible for determining the effectiveness of stormwater pollution load reduction activities in achieving covered fish species benefits.

Problem statement: Stormwater runoff has been identified as the leading source of water pollution in the United States (Lee et al. 2007) and is thought to be a large contributor to toxic loads present in the Delta (Weston et al. 2005, Amweg et al. 2006, Werner et al. 2008). As stormwater runoff returns to the Delta, it accumulates sediment, oil and grease, pesticides, and many other toxic chemicals. Unlike sewage, stormwater is not treated by stormwater agencies before entering the Delta. Regulation of and reductions in runoff are ongoing (EPA 1993).

All major urban centers in the Delta, including Sacramento, Stockton, and Tracy, and multiple smaller cities are under National Pollutant Discharge Elimination System (NPDES) MS4 permits

to develop and implement a Storm Water Management Plan/Program with the goal of reducing the discharge of pollutants to the maximum extent practicable under Section 402(p) of the Clean Water Act. These permits require development and implementation of a Storm Water Management Plan/Program to meet this goal.

Hypotheses: Reducing the amount of pollution in stormwater runoff entering Delta waterways is hypothesized to provide benefits to fish species through the following mechanisms.

1. Reducing direct mortality of splittail, delta and longfin smelt, green and white sturgeon, steelhead, and Chinook salmon (all races) from contaminants. Weston et al. (2009) found that residential runoff is a larger source of pyrethroid pesticides than agricultural runoff. Pyrethroids are known to affect aquatic organisms in the Delta, including covered fish species and their food (Weston et al. 2005, Werner et al. 2008) (see OSCM4 for more information).

2. Reducing sublethal effects (behavior, tissue/organ damage, reproduction, growth, and immune) of contaminants on splittail, delta and longfin smelt, green and white sturgeon, steelhead, and Chinook salmon (all races). Pyrethroids and other chemicals from urban and stormwater run-off can reduce the health of covered fish species. Suspended sediment in high concentration can impair respiration and reduce the growth rate of fish (e.g., Sutherland and Meyer 2007).

3. Increasing food abundance for splittail, delta and longfin smelt, green and white sturgeon, steelhead, and Chinook salmon (all races). Pesticides and herbicides can be highly toxic to invertebrates and phytoplankton, which form the base of the food web or are important prey species for covered fish species (Amweg et al. 2005, Weston et al. 2005, Stoiber et al. 2007). Further, suspended sediment is the primary attenuator of sunlight in the water column and thus can reduce photosynthesis in phytoplankton and submerged aquatic vegetation and affect fish behavior and health in the Delta (Schoelhammer et al. 2007).

Adaptive management considerations: The Implementing Entity will provide ongoing review of monitoring, progress, and other relevant reports from the stormwater agencies related to the effectiveness the Program for reducing contaminant loads in stormwater runoff. The Implementing Entity will coordinate with the stormwater agencies to adjust stormwater pollution reduction strategies and funding levels through the BDCP adaptive management process as appropriate based on review of results of effectiveness monitoring and stormwater agency monitoring and other relevant reports.

The BDCP Implementing Entity would use results of effectiveness monitoring to determine if reducing stormwater pollution loads results in measurable benefits to covered fish species and to identify adjustments to funding levels, control methods, or other related aspects of the program that would improve the biological effectiveness of the program. Such changes would be effected through the BDCP adaptive management process and would be included in the subsequent annual work plans.

If results of monitoring indicate that reducing stormwater pollution loads does not substantially and cost-effectively benefit covered fish species, the BDCP Implementing Entity in coordination with Fishery Agencies may terminate this conservation measure. If terminated, remaining funding would be deobligated from this conservation measure and reallocated to augment funding for other more effective conservation measures identified in coordination with the Fishery Agencies through the BDCP adaptive management process.

The BDCP Implementing Entity in coordination with the Fishery Agencies may discontinue effectiveness monitoring for this measure in future years if monitoring results indicate a strong correlation between reduction in stormwater pollution loads entering the Delta and responses of covered fish species.

OSCM7: Maintain Dissolved Oxygen Levels Above Levels that Impair Covered Fish Species in the Stockton Deep Water Ship Channel during Periods when Covered Fish Species are Present. *[**Note to reviewers**: SAIC is currently in discussion with DWR regarding the results of their ongoing oxygen diffuser demonstration project. Due to the recent bond spending freeze, results of this demonstration study are not anticipated to be available in the near future. This conservation measure will be updated as new information becomes available]*. The BDCP Implementing Entity will operate and maintain an oxygen diffuser(s) in the Stockton Deep Water Ship Channel to increase dissolved oxygen concentrations between Turner Cut and Stockton to meet Total Maximum Daily Load (TMDL) objectives established by the CVRWQCB (2005) (above 6.0 mg/L from September 1 through November 30 and above 5.0 mg/L at all times). Operations and maintenance (O&M) for the diffuser would cost $_____ per year. The existing diffuser would be modified as necessary and additional diffusers and associated infrastructure would be added to optimize oxygen delivery to the river, contingent upon results of an ongoing demonstration project conducted by DWR.

The BDCP Implementing Entity would be responsible for developing annual work plans in coordination with Fishery Agencies that specify the extent of dissolved oxygen improvements to be implemented and would be responsible for monitoring the effectiveness of dissolve oxygen enhancement measures in improving dissolved oxygen levels.

Problem statement: The Stockton Deep Water Ship Channel has been identified as an impaired waterway by the State Water Resources Control Board because of low dissolved oxygen concentrations during late summer and early fall (CVRWQCB 2005). The combination of low flows, high loads of oxygen-demanding substances (algae from upstream, effluent from the City of Stockton Regional Wastewater Control Facility, and other unknown sources), and channel geometry contribute to low oxygen levels in the Stockton Deep Water Ship Channel (CVRWQCB 2005). The Stockton Deep Water Ship Channel often exceeds water quality objectives established by the Regional Board for dissolved oxygen (CVRWQCB 2007b). The 12 mile low dissolved oxygen area of the ship channel creates a barrier for upstream migration of adult fall-run Chinook salmon and Central Valley steelhead on the mainstem of the San Joaquin River (Hallock et al. 1970). Further, low dissolved oxygen levels can cause physiological stress on and mortality of fish, including Chinook salmon and steelhead (Jassby and Van Nieuwenhuyse 2005), and other aquatic organisms (CVRWQCB 2007b). Once spring-run Chinook salmon are re-established in the San Joaquin River under the San Joaquin River Litigation Settlement, dissolved oxygen sags in the Deep Water Ship Channel will likely have similar effects on this run if sags were to occur during their adult migration period (expected to be approximately March-September).

One potential solution to dissolved oxygen sags in the Stockton Deep Water Ship Channel, a dissolved oxygen aeration system, has been installed and is currently undergoing field testing by DWR. Limited analysis of 2008 results suggests that the diffuser was successful in delivering oxygen to the river. This oxygen aeration project has been funded with Proposition 13 money, which can only be used for demonstration purposes. Long-term funding for operations and maintenance has not yet been secured and there are currently no mandates by the CVRWQCB that require contributors to the cause to fund the project. Under this conservation measure, the BDCP would fund the long term O&M costs associated with the project.

Hypotheses: Increasing dissolved oxygen concentrations in the Stockton Deep Water Ship Channel in accordance with TMDL objectives is hypothesized to result in:

- Reduced delay and inhibition of upstream and downstream migration of fall-run Chinook salmon, steelhead, white sturgeon, splittail, and, once they are re-established in the San Joaquin River, spring-run Chinook salmon; and
- Reduced physical stress and mortality of fall-run Chinook salmon, steelhead, white sturgeon, green sturgeon, splittail, and, once they are re-established in the San Joaquin River, spring-run Chinook salmon.

Adaptive management considerations: Results from monitoring of dissolved oxygen levels at various distances from the diffuser(s) would be used to identify the need to improve the effectiveness of the oxygen diffuser facilities and operations for achieving the TMDL through BDCP adaptive management decision making process.

OSCM10: Reduce the Risk for Future Introductions of Non-Native Aquatic Organisms from Recreational Watercraft. *[**Note to Reviewers**: SAIC is currently in discussion with DFG regarding the practicability of implementing this conservation measure. Additional detail will be added to the conservation measure as it becomes available]* The BDCP Implementing Entity will provide funding up to $____ over the term of the BDCP to support a recreational watercraft inspection program of the California Department of Fish and Game (DFG) to prevent future invasions of non-natives into the Delta. It is anticipated that the program will establish a certificate or similar program whereby boats and trailers entering Delta waterways would be required to be inspected for evidence of non-native species. If free of standing water and organisms, the boat and/or trailer would be given a certificate to allow entry into Delta waterways for a set number of days. Multiple inspection stations will be set up along major driving routes throughout the Delta. Each inspection station will have an associated washing station with necessary equipment and materials to clean watercraft, if possible. The program could be operated under the auspices of DFG game wardens, potentially as part of DBEEP. Funding will be provided to implement the certificate program and increase the number of watercraft inspections over the level provided under current funding and staffing resources. Funding will be sufficient to support up to __ additional wardens over existing staffing levels and an annual training program (or refresher) on aquatic invasive species identification, disposal, and reporting methods. Initial stages of the program will determine the level of effort and geographical extent needed for the program. Public outreach and education are implicitly necessary for the program to be implemented effectively.

The BDCP Implementing Entity will enter into a Memorandum of Agreement (MOA) or similar binding instrument with DFG as described in Section 3.4.3.1. The MOA will specify that DFG will be responsible for monitoring the effectiveness of the inspection program and inspection methods to improve their effectiveness over time, if necessary.

Problem statement: A primary vector of local introductions of aquatic non-native species is recreational watercraft and trailers used to transport them (DFG 2008). Non-native species can become attached to the hulls and engines of watercraft or various parts of trailers or be transported in standing bilge water or live bait tanks. Since the invasion of quagga mussels into Southern California waterways in January 2007, the California Department of Food and Agriculture and DFG boat inspection efforts at California borders have increased and many lakes and reservoirs have begun mandatory inspection programs. However, there is currently no comprehensive effort to inspect boats entering Delta waterways. To prevent new aquatic species invasions effectively in the Delta, a comprehensive inspection program needs to be developed and implemented.

Hypotheses: Increasing inspection efforts of watercraft by trained experts is hypothesized to increase the identification and subsequent removal of non-natives from watercraft, thereby reducing the risk of introduction into the Delta and reducing the deleterious effects that non-native species introductions and invasions can have on covered species in the Delta. If the effects of past introductions are an indication of the effects of future introductions, there will likely be large ecosystem scale effects of non-natives introduced in the Delta in the future. Therefore, reducing the risk for future introductions of non-native aquatic organisms from commercial vessels is hypothesized to reduce the potential for negative effects of non-native aquatic species on the covered fish species and the Delta ecosystem. Although it is not possible to predict the actual potential effects of future introductions of non-native species, there are several well-documented examples of deleterious effects caused by the introduction of non-native species into the Delta. Two non-native invasive aquatic plants, water hyacinth (*Eichhornia crassipes*) and Brazilian waterweed (*Egeria densa*), have reduced habitat quantity and quality for many native fishes in the Planning Area (NMFS 2004), and possibly provide habitat for non-native predatory centrarchids. The introductions of two clams from Asia, the overbite clam (*Corbula amurensis*) and the Asian clam (*Corbicula fluminea*), have resulted in substantial changes to ecosystem dynamics in the Delta in just 20 years. These clams are considered ecosystem modifiers because of their wide ranging effects on the aquatic ecosystem and specific native species. Both are highly efficient filter feeders that reduce phytoplankton and zooplankton in the water column, which can be food for native fishes, such as delta smelt and juvenile Chinook salmon (Kimmerer and Orsi 1996, NMFS 2004, Center for Biological Diversity 2007). Several introduced invertebrate species that are food for several covered fish species have replaced native species in the low salinity zone, and may have led to lower foraging efficiency, starvation, and reduced growth rates of these fishes (Moyle 2002). Recent introductions of quagga and zebra mussels into southern California, likely via recreational watercraft, have indicated a need to develop a Delta-specific watercraft inspection program to slow and contain the spread of the mussels across the state, particularly with respect to the Delta.

Adaptive management considerations: The BDCP Implementing Entity will review DFG monitoring and other relevant reports to assess the effectiveness of the program in reducing risk for the introduction and establishment of non-native species. The BDCP Implementing Entity will coordinate with DFG to adjust inspection strategies and funding levels through the BDCP adaptive management decision making process as appropriate. If results of effectiveness monitoring indicate that the inspection program does not substantially and cost-effectively reduce the risk of introductions of non-native aquatic species into the Delta aquatic ecosystem, the BDCP Implementing Entity, in coordination with Fishery Agencies, may terminate this conservation measure. If terminated, remaining funding would be deobligated from this conservation measure and reallocated to augment funding for other more effective conservation measures identified in coordination with the Fishery Agencies through the BDCP adaptive management decision making process.

OSCM11: Improve the rapid detection of and rapid response to new non-native species introductions into Delta waterways. *[**Note to reviewers:** The emphasis of this measure is the monitoring component; however, SAIC is currently in discussions with DFG's Invasive Species Program and OSPR regarding additional detail on the response that will be provided in subsequent document versions]*. The BDCP Implementing Entity will fund the DFG Oil Spill Prevention and Response (OSPR) aquatic species monitoring program and a DFG volunteer invasive early detection network to increase non-native early detection capability in the Bay-Delta and will work with DFG to support their rapid response program. The BDCP Implementing Entity will support the DFG OSPR aquatic species

monitoring program at a funding level of $200,000 for the initial survey and approximately $150,000 each subsequent year over the term of the BDCP (it is assumed that the cost would decrease after the initial survey due to increased efficiency) (S. Foss pers. comm.). The BDCP Implementing Entity will support the DFG Invasive Species Program's establishment and maintenance of a volunteer invasive early detection network at a funding level of $100,000 per year over the term of the BDCP (S. Ellis pers. comm.). This network will be administered by the DFG Education and Outreach staff person and would use volunteers that may include dive groups or others already engaged in activities that allow for monitoring activities. The network will not necessarily be scientific or systematic in nature unlike the OSPR monitoring program. The goal of both programs will be to increase the ability to detect new non-native species at an early stage to allow for rapid responses to eradicate the species. The programs will be coordinated to minimize duplicative efforts in monitoring activities.

A 2005 Delta survey completed by the USFWS (USFWS 2007) will serve as the baseline for the OSPR monitoring program and similar protocols and methods used in that survey will be used in future surveys under this measure (S. Foss pers. comm.). Consistent with the USFWS survey, future monitoring will target three main ecological communities: subtidal epifaunal communities, subtidal infaunal communities, and invertebrate species associated with floating plant communities. Sampling will include qualitative and quantitative sampling protocols to survey for the presence of non-native species. Methods employed may include the use of sediment cores and grabs, quadrat clearings, qualitative taxonomic surveys, hand collection of floating plants and their roots, and other techniques deemed necessary by OSPR. Samples will be preserved and individuals will be identified to species if possible and enumerated. The sampling strategy will include multiple depths, substrates, orientations and light exposure conditions to encompass the diversity of potential habitat preferences in larval recruitment and subsequent colonization.

In addition to funding, the BDCP Implementing Entity would assist and coordinate with DFG to meet other elements of a successful rapid response program:

1. Obtaining legal authority to take action;
2. Developing a mechanism or process by which to agree upon species targeted for eradication; and
3. Developing a mechanism or process by which to agree upon control strategies, and clear them of regulatory hurdles.

This conservation measure would contribute funding to form a rapid response team specific to the Delta by specifying that these monies fund actions in the Delta or at locations outside the Delta for species with a high likelihood of invading the Delta.

The BDCP Implementing Entity will enter into a Memorandum of Agreement (MOA) or similar binding instrument with DFG as described in Section 3.4.3.1.

Problem statement: The California Aquatic Invasive Species Program includes an action recommending the development of "species- and/or location-specific rapid response plans" (DFG 2008). The Draft Rapid Response Plan states that "the Plan cannot be implemented without adequate, stable and dedicated funding" (DFG 2008). This conservation measure would partially or wholly provide this funding.

Hypotheses: Providing for rapid detection of and response to new introductions of non-native species is hypothesized to increase the identification, immediate response, and eradication of new introductions of non-natives in Delta waterways, reducing the deleterious effects that non-native species introductions and invasions can have on covered species in the Delta. Any delay in response could allow for establishment of a non-native species over an area too large for

eradication efforts. By identifying and stopping invading species before they become well established, this measure could prevent substantial adverse effects on covered species as evidenced by past non-native invasions. Threats to the Delta ecosystem that could be associated with future establishment of new non-native species in the Delta are described above in OSCM10.

Adaptive management considerations: The BDCP Implementing Entity would review progress reports or other relevant reports prepared by DFG to assess the effectiveness of the Delta-specific rapid response team in preventing the establishment of new invasive non-native species in the Delta. The BDCP Implementing Entity would coordinate with DFG to adjust invasive species control strategies and funding levels through the BDCP adaptive management process as appropriate, based on results of effectiveness review, DFG monitoring and other relevant reports.

The BDCP Implementing Entity would use results of effectiveness review to determine if non-native species monitoring results in measurable benefits to covered fish species and to identify adjustments to funding levels, control methods, or other related aspects of the program that would improve the biological effectiveness of the program. Such changes would be effected through the BDCP adaptive management process and would be included in the subsequent annual work plans.

If results of review indicate that non-native species monitoring does not substantially and cost-effectively benefit covered fish species, the BDCP Implementing Entity in coordination with Fishery Agencies may terminate this conservation measure. If terminated, remaining funding would be deobligated from this conservation measure and reallocated to augment funding for other more effective conservation measures identified in coordination with the Fishery Agencies through the BDCP adaptive management process.

OSCM12: Reduce the Risk for Establishment of Zebra Mussel and Quagga Mussel in Delta Waterways. *[**Note to reviewers**: SAIC is currently in discussions with DFG's Invasive Species Program on the specifics and feasibility of individual actions. Additional detail will be added as it becomes available] The* BDCP Implementing Entity will provide up to $$_____ over the term of the BDCP to support implementation of the following actions:

1. Complete annual updates of the Zebra Mussel Rapid Response Plan for California to include quagga mussel (*Dreissena rostriformis bugensis*) and incorporate eradication scenarios that reflect the operations and covered species data that are generated by the development and implementation of the BDCP. The scenarios would include a full range of possible invasion patterns, invasion extents, covered species distributions and life history sensitivities, and water status and operation patterns that represent drought and normal rainfall water years;
2. Apply to the EPA for the appropriate permits to use potassium salt solution and/or the common soil bacterium, *Pseudomonas fluorescens*, as control measures and develop a draft template Environmental Assessment for USFWS and NOAA that is reviewed annually to incorporate the latest data specific to the Delta. Similar templates would be developed for the appropriate State agencies' compliance with CEQA;
3. Conduct mussel control experiments to evaluate a range of potassium chloride salt and *P. fluorescens* solution delivery options in waterways of different sizes and hydrological dynamics;
4. Conduct research on the effects of potassium chloride salt and *P. fluorescens* on covered fish species; and
5. Endow a control program with permanent funding to cover eradication efforts.

The BDCP Implementing Entity will enter into Memoranda of Agreement (MOAs), contracts, or other binding instruments as described in Section 3.4.1.1 with appropriate entities as needed to implement this conservation measure. Funded entities would be responsible for implementing the scopes of work and submitting reports as specified in the agreements that demonstrate that work plans are successfully implemented.

Problem statement: The likelihood of invasion of zebra and/or quagga mussels in the Delta is thought to be imminent since the 2007 introductions of quagga mussels in Lake Mead and a number of other locations in southern California, and the 2008 introduction of zebra mussels into San Justo Reservoir. The Zebra Mussel Rapid Response Plan for California and its appendices contain a series of rapid response actions and control alternatives that were written specifically for the Delta and intended to be used as a template for other bodies of water (Messer and Veldhuizen 2005). In its current form, the Zebra Mussel Rapid Response Plan for California anticipates that control options and permits would be applied after either zebra or quagga mussels are detected and it provides a number of scenarios and potential control responses that are specific to the Delta. The response to the Lake Mead infestation has been studied and a number of recommendations for a rapid response program have been proposed (California Science Advisory Panel 2007). The included recommendations provide for a management structure that will permit an efficient response (M. Volkoff, pers. comm.) but does not address control or management methods. The report also notes that the lack of a dedicated rapid response funding source caused many of the Lake Mead managers to spend a significant amount of their time trying to obtain funding and staff instead of responding to the emergency.

Hypotheses: Reducing the risk for establishment of zebra and quagga mussels in Delta waterways is hypothesized to help protect covered fish species and the Delta ecosystem from the deleterious effects that such an establishment could bring. Although it is difficult to determine the actual deleterious effects of the introductions of these species, it is hypothesized that effects would be similar to those caused by the mussels in other parts of North America. Quagga and zebra mussel invasions have had major ecosystem level effects to other water bodies and waterways in North America (Fahnenstiel et al. 1995a,b, Lowe and Pillsbury 1995, Ricciardi 1997, Stewart et al. 1998). The mussels reduce planktonic food abundance for other native planktivores. Both mussel species attach to hard substrata, reducing available substrate for native species. The mussels will even colonize on native species with hard surfaces, including other mussels, clams, crayfish, and turtles, likely reducing their ability to move, hide, and/or capture prey effectively. The introduction of these mussels in the Mississippi River basin is believed to have caused >90% mortality of native bivalves (Ricciardi et al. 1996).

Adaptive management considerations: The agencies charged with implementing the Zebra Mussel Rapid Response Plan for California would be responsible for monitoring the effectiveness of BDCP-funded elements of the program. The BDCP Implementing Entity will review monitoring and other relevant reports prepared by the agencies to assess the effectiveness of the program in reducing risk for the introduction and establishment of zebra and quagga mussels. The BDCP Implementing Entity would coordinate with the agencies to adjust mussel control strategies and funding levels through the BDCP adaptive management process as appropriate, based on review of agency reports.

The BDCP Implementing Entity in coordination with the Fishery Agencies will periodically review the cost effectiveness of this conservation measure in achieving benefits for covered fish species. If it is determined that this conservation measure does not provide a substantial cost-effective benefit for covered fish species, the BDCP Implementing Entity in coordination with

Fishery Agencies may terminate this conservation measure. If terminated, remaining funding would be deobligated from this conservation measure and reallocated to augment funding for other more effective conservation measures identified in coordination with the Fishery Agencies through the BDCP adaptive management decision making process.

OSCM13: Remove Non-Native Submerged and Floating Aquatic Vegetation from Delta Waterways. *[**Note to reviewers**: SAIC is in discussions with the Department of Boating and Waterways to refine and provide more detail to this conservation measure. More information will be added as it becomes available]* The BDCP Implementing Entity will fund the removal of Brazilian waterweed (Egeria densa), water hyacinth (Eichhornia crassipes), and other non-native submerged and floating aquatic vegetation (SAV and FAV) from __ acres of Delta waterways. To implement this conservation measure, the BDCP will support the California Department of Boating and Waterways (DBW) Egeria densa and Water Hyacinth Control Programs and applicable future non-native aquatic vegetation control programs to reduce the impacts of SAV and FAV on covered fish species at a funding level of $_____ over the term of the BDCP[2].

Unlike the focus of DBW's current programs, which identifies target treatment locations based on impacts to navigability of waterways, SAV/FAV removal using BDCP funds will focus on areas that provide the greatest biological benefits to covered fish species. Prioritization for specific areas for treatment will be according to the following tiers:

1. BDCP restored aquatic habitat (Figure 3.X);
2. Salmonid migration routes (Figure 3.X); and
3. Other areas deemed biologically important to covered fish species by the BDCP Implementing Entity.

Annual target acreages for the removal of SAV/FAV will vary according to tier: BDCP restored aquatic habitat-- __ acres, salmonid migration routes-- __ acres, and other biologically important areas-- __ acres. The BDCP Implementing Entity will ensure the maintenance of areas cleared of SAV and FAV over the term of the BDCP.

The BDCP Implementing Entity will enter into a Memorandum of Agreement (MOA) or similar binding instrument with DBW as described in Section 3.4.3.1. The BDCP Implementing Entity will implement this conservation measure if DBW does not choose to participate in its implementation.

Problem statement: Although the historical extent of native SAV and FAV in the Delta ecosystem is unknown, non-native invasive SAV and FAV species have recently invaded large areas of the Delta (Brown 2003, DFG 2008, Ustin et al. 2008) and the invasion is continuing to expand into a greater proportion of channels and colonize new areas (IEP 2008b). The widest spread non-native FAV species, water hyacinth, was introduced into the Delta over 100 years ago and severe infestations were experienced by the 1980s. The majority of the surface cover of SAV detected through the recent use of airborne hyperspectral imagery is *Egeria densa*, although the SAV vegetation frequently contains a mixture of three invasive non-native species: *Egeria densa*, *Potamogeton crispus* (curlyleaf pond weed), and *Myriophyllum spicatum* (Eurasian watermilfoil)

[2] The budget for the combined *Egeria densa* and Water Hyacinth Control Program in fiscal years 2005/2006 and 2007/2008 was $7,000,000 with regulatory costs up to 65% of the control costs (DBW 2006, DFG 2008), although regulatory costs are anticipated to be lower in the future once DBW completes preliminary toxicology and monitoring work.

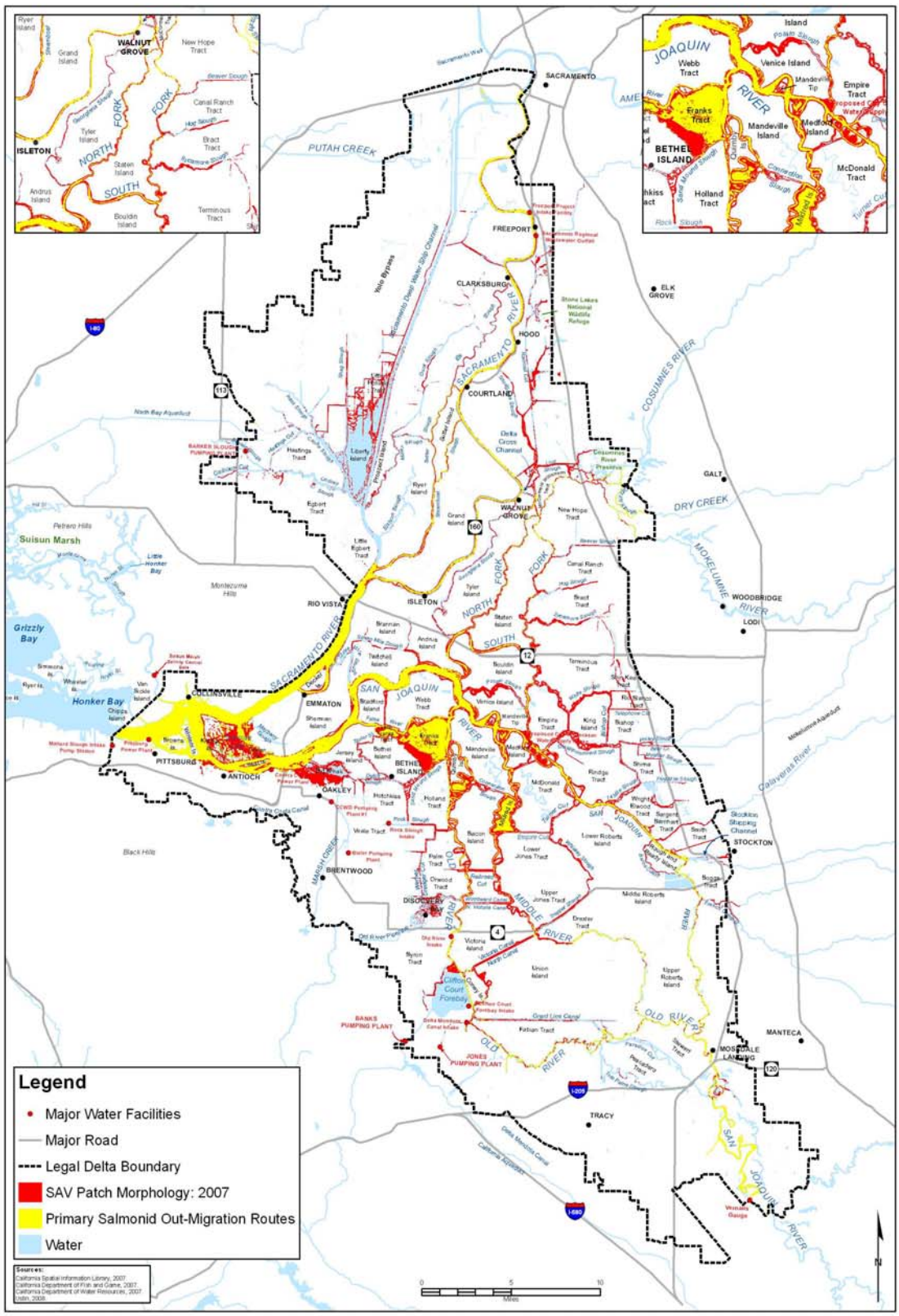

Figure 3.X. **Overlap of SAV in 2007 and Primary Salmonid Outmigration Routes.**

(Ustin et al. 2008). Of the 55,000 acres of the Delta surveyed in 2007, SAV cover has been estimated to be between 5,500 and 10,000 acres (Ustin et al. 2008). Non-native SAV and FAV are thought to cause multiple negative effects on the Delta ecosystem, including providing habitat for non-native predators of covered fish species (Brown 2003), reducing food abundance and feeding ability of covered fish species by reducing light and turbidity (Brown and Michniuk 2007), and blocking rearing habitat for juvenile salmon and splittail (IEP 2008a).

The DBW's Water Hyacinth Control Program, which began in 1982, has been effective in reducing hyacinth from Delta waterways using chemical and mechanical removal methods. DBW developed and has operated the *Egeria densa* Control Program (EDCP) since 2001 in response to AB 2193, which amended the Harbors and Navigation Code to designate DBW as the lead agency for the control of *Egeria densa* in the Delta (DBW 2006, 2008). Initially, the program focused control efforts in a number of locations where *Egeria* impeded navigation, on a range of mechanical and chemical control techniques, and on an extensive suite of toxicology and water quality tests and sampling that were required by the terms of its National Pollution Discharge Elimination System (NPDES) permit and under biological opinions issued by USFWS and NOAA Fisheries (DBW 2008). In 2006, DBW concluded that its current approach was not effective and proposed expanding the treatment area to sites across most of the legal Delta between 2006-2010 and concentrating on Franks Tract between 2006-2008 (DBW 2006). DBW (2006) stated that they would seek alternative and supplemental resources and funding to support these efforts.

The primary focal areas for removal of both the Egeria densa Control Program and the Water Hyacinth Control Program have been those in which navigation by boats has been blocked. However, many smaller sloughs and cuts that are not designated as navigable can become filled with non-native SAV and FAV, contributing to their negative effects on covered fish species.

Hypotheses: Removing non-native SAV and FAV from Delta waterways is hypothesized to provide benefits to covered fish species through the following mechanisms.

1. Reducing predation mortality on juvenile salmon, steelhead, and splittail by reducing habitat for non-native predatory fish. SAV provides relatively high quality habitat for non-native piscivores and is spread across large portions of the Delta in or adjacent to significant migration corridors and pelagic and subtidal open water habitat for covered species (Figure 1). The interior of SAV stands is hypothesized to be good habitat for larval and juvenile centrarchids, particularly largemouth bass (Brown 2003, Grimaldo et al. 2004), whereas adult largemouth centrarchids hunt immediately outside of the SAV bed and feed on juvenile Chinook salmon and splittail (Brown 2003, IEP 2008a), and possibly steelhead, delta smelt, and longfin smelt.
2. Reducing predation mortality of delta smelt by increasing turbidity levels (IEP 2008a). SAV and FAV are thought to reduce local flow rates and cause suspended solids to precipitate out of the water column, resulting in a localized reduction in turbidity levels (Grimaldo and Hymanson 1999). A reduction in turbidity is hypothesized to reduce the predator avoidance abilities in delta and longfin smelt. In addition, reduced turbidity may increase the hunting efficiency of non-native piscivores (Nobriga et al. 2005).
3. Increasing food consumption by delta and longfin smelt by increasing turbidity levels. SAV and FAV are thought to reduce local flow rates and cause suspended particles to precipitate out of the water column, resulting in a localized reduction in turbidity levels

(Grimaldo and Hymanson 1999). A reduction in turbidity is hypothesized to reduce the foraging ability of delta and longfin smelt.

4. Increasing rearing habitat for juvenile salmon (all races), steelhead, and splittail. Dense patches of SAV and FAV physically obstruct covered fish species access to habitat (IEP 2008a) that would become available with SAV and FAV removal and control. .

5. Increasing food availability for all covered fish species near removal locations by increasing light levels below vegetation. Phytoplankton growth is light limited in the Delta (Cole and Cloern 1984). The further reduction in light levels near non-native SAV and FAV are thought to reduce local growth of phytoplankton, which may drive the local abundance of zooplankton that form the food base for covered fish species near patches of SAV and FAV.

Adaptive management considerations: The DBW would be responsible for monitoring the effectiveness of BDCP-funded elements of the non-native aquatic vegetation control programs in successfully controlling SAV and FAV. The BDCP Implementing Entity would review monitoring other relevant reports prepared by the DBW to assess the effectiveness of the program for controlling non-native aquatic vegetation in the Delta. The BDCP Implementing Entity would coordinate with the DBW to adjust inspection strategies and funding levels through the BDCP adaptive management process as appropriate based on review of program reports. The BDCP Implementing Entity would use results of effectiveness monitoring to determine if reducing controlling SAV and FAV results in measurable benefits to covered fish species and to identify adjustments to funding levels, control methods, or other related aspects of the program that would improve the biological effectiveness of the program. Such changes, once approved through the adaptive management decision making process, will be effected through subsequent annual work plans. If results of monitoring indicate that removing and controlling SAV and FAV does not substantially and cost-effectively benefit covered fish species, the BDCP Implementing Entity, in coordination with Fishery Agencies, may terminate this conservation measure. If terminated, remaining funding would be deobligated from this conservation measure and reallocated to augment funding for other more effective conservation measures identified in coordination with the Fishery Agencies through the BDCP adaptive management process.

OSCM16: Reduce Illegal Harvest of Chinook Salmon, Central Valley Steelhead, Green Sturgeon, and White Sturgeon in the Delta. *[**Note to Reviewers**: SAIC is currently in discussion with DBEEP officials regarding the specifics of this conservation measure and its implementation. The text for this measure will be updated as new information becomes available.]* The BDCP will provide funding to increase the enforcement of fishing regulations in the Delta and Bays to reduce illegal harvest of covered salmonids and sturgeon. The BDCP Implementing Entity will provide funds to DFG to support and equip the addition of 17 field wardens and 5 supervisory and administrative staff in support of the field wardens assigned to the Delta-Bay Enhanced Enforcement Program (DBEEP) over the term of the BDCP. Estimated funding will be $8.7 million for the first year of implementation and an estimated annual cost of $6.7 million in subsequent years without inflation. The goal of the conservation measure would be to reduce illegal harvest by __ percent from estimated 200_ levels.

The Delta-Bay Enhanced Enforcement Program (DBEEP) is a 10 warden squad that was formed specifically to increase enforcement on poaching of anadromous fish species in Bay-Delta waterways. The program is funded by water contractors through the Four-Pumps Agreement Advisory Committee. The BDCP would contribute directly to this existing program by expanding its size to improve enforcement on poaching of covered species.

The BDCP Implementing Entity will enter into Memoranda of Agreement (MOAs) or similar binding instruments with DFG as described in Section 3.4.3.1.

Problem statement: California has the lowest game warden to population ratio in the nation with fewer than 200 field wardens for the entire state. The Delta is a particular hot spot for poaching because of the large number of sport fish, particularly gravid female white sturgeon, whose roe are used for caviar (Lt. L. Schwall, pers. comm.). Illegal harvest is thought to have high impacts on sturgeon populations, particularly white sturgeon (Beamsderfer et al. 2007). Illegal harvest of juvenile and adult Chinook salmon and steelhead in the Delta and Bays is also common (DBEEP 2007).

Hypotheses: It is hypothesized that enhanced enforcement on poaching will reduce mortality, and potentially increase population sizes, of green sturgeon (Beamesderfer et al. 2007, CDFG unpublished, Boreman 1997, D. Tanner pers. comm., DBEEP 2007); white sturgeon (Bay-Delta Oversight Council 1995, Boreman 1997, Schaffter & Kohlhorst 1999, Beamesderfer et al. 2007, DBEEP 2007, DFG Sturgeon Report Card 2007, M. Gingras pers. comm., Z. Matica pers. comm., CDFG unpubl. data); Chinook salmon (all races) (Bay-Delta Oversight Council 1995, Williams 2006); and steelhead (DBEEP 2007, DFG Steelhead Report Card 2007, DFG Creel Survey 2007-08, Moyle et al. 2008).

Magnitudes of population-level benefits of this measure are expected to vary inversely with the population size of each covered species (Bay-Delta Oversight Council 1995, Begon et al. 1996, Futuyma 1998, Moyle et al. 2008).

Adaptive management: The BDCP Implementing Entity would coordinate with DFG to adjust enforcement strategies and funding levels through the BDCP adaptive management process as appropriate based on review of Program reports.

OSCM18: Develop and Implement Hatchery and Genetic Management Plans to Minimize the Potential for Genetic and Ecological Impacts of Hatchery Reared Salmonids on Wild Salmonid Stocks. *[**Note to reviewers**: SAIC is in discussion with individual hatcheries to determine the details of this conservation measure. Additional detail will be added to this measure as it becomes available]* The BDCP Implementing Entity will minimize potential adverse effects of hatchery reared salmonids on wild salmonid stocks by supporting the accelerated development and implementation of Hatchery and Genetic Management Plans (HGMPs) for all Chinook salmon and steelhead hatcheries in the Central Valley of California at a funding level of $$_____ over the term of the BDCP. HGMPs would be implemented to reduce adverse ecological and genetic effects of hatcheries on wild fish.

The BDCP Implementing Entity will enter into Memoranda of Agreement (MOAs) or similar binding instruments with DFG as described in Section 3.4.3.1.

Problem statement: Hatchery-reared Chinook salmon and steelhead are believed to have negative effects on wild Chinook salmon and steelhead, including competition for space and food as juveniles and for spawning habitat as adults. Fish reared in hatcheries can be selected for traits that are different from those in nature, such as those that allow them to survive in an artificial, contained environment (e.g., fast growth, large size). This could result in reduced genetic isolation of hatchery fish from wild fish. It is thought that these hatchery fish outcompete their smaller wild-reared conspecifics for food and space in natural waterways (Williams 2006). Also, as adults, straying by hatchery reared salmon into natural spawning grounds may lead to genetic introgression, where offspring of wild salmon are "genetically polluted" with hatchery-selected

genes, thereby reducing the fitness of wild population (ISAB 2003, Goodman 2005, Hey et al. 2005).

To address these concerns, hatcheries have begun reforming their management practices to minimize the effects that hatchery fish may have on wild fish. HGMPs serve as the foundation of hatchery management and reform to minimize genetic and ecological impacts to wild fish. HGMPs are developed to devise and evaluate practices of a hatchery to ensure the hatchery contributes to the conservation and recovery of listed salmonids.

Although required, the development of HGMPs in Central Valley hatcheries has been slow to date.

Hypotheses: Accelerating the development and implementation of HGMPs at Central Valley hatcheries is hypothesized to:

- improve the genetics and fitness of wild salmonids (ISAB 2003, Goodman 2005, Hey et al. 2005); and
- reduce competition for rearing and spawning habitat and food with hatchery reared salmonids (Flagg et al. 2000, Goodman 2005).

Adaptive management considerations: The Implementing Entity will coordinate with the individual hatcheries to adjust HGMP strategies and funding levels through the BDCP adaptive management process as appropriate based on review of annual reports.

OSCM20: Establish New and Expand Existing Conservation Propagation Programs for Delta and Longfin Smelt. The BDCP Implementing Entity will support: (1) the development of a delta and longfin smelt conservation hatchery by the USFWS to house a delta smelt refugial population and provide a source of delta and longfin smelt for supplementation or reintroduction, if deemed necessary by Fishery Agencies, and (2) the expansion of the refugial population of delta smelt and establishment of a refugial population of longfin smelt at the University of California, Davis Fish Conservation and Culture Laboratory to serve as a population safeguard in case of a catastrophic event in the wild.

The new facility proposed by the USFWS would house genetically-managed refugial populations of delta and longfin smelt (Clarke 2008). Further, the facility would provide fish to supplement the wild population and provide fish stocks for reintroduction, as necessary and appropriate. State-of-the-art genetic management practices would be implemented to avoid hatchery produced fish becoming genetically different from wild fish. The facility would be designed with the ability to add other species if necessary in the future. Construction and start-up costs are estimated to be $19.5 million. Annual operating costs are estimated to be $1.5-2.0 million. Specific rules would be established to discontinue housing refugial populations of delta and longfin smelt at the hatchery if and when populations of these species are considered recovered by Fishery Agencies.

In addition, the UC Davis Fish Conservation and Culture Laboratory (FCCL) is in need of additional space and funds to expand the refugial population of delta smelt and establish a refugial population of longfin smelt. The FCCL and the Genomic Variation Laboratory (GVL) at UC Davis is, and will be, the primary entities developing and implementing genetic management of the delta smelt refugial population over the period 2009-2015 or longer and may then play a secondary role in keeping a back-up population(s). UC Davis cost estimates include a one time expansion cost of $2.56 million for physical expansion of the existing site, but substantially more funds may be required to pay for existing building (and more than double this figure if a new site is required), and an estimated $1.2 million for annual operating costs (FCCL - $1M and GVL - $200K). UC Davis and the GVL have not developed cost

estimates for developing and implementing genetic management for a longfin smelt conservation hatchery at this time.

At both facilities, genetic management practices would be implemented to maintain wild genetic diversity, minimize genetic adaptation to captivity, minimize mean kinship, and equalize family contributions. Furthermore, genetic monitoring of wild populations would proceed to minimize risks such as: genetic swamping from the hatchery population, reduction in effective population size, and changes in the census population-to-breeder population ratio over time.

The BDCP Implementing Entity would enter into Memoranda of Agreement (MOAs) or similar binding instruments with the USFWS and University of California, Davis similar to that described in Section 3.4.3.1 with the addition of a description of Hatchery and Genetic Management Plan (HGMP) development and implementation. In addition, if and when populations of these species are considered recovered by the Fishery Agencies, the BDCP Implementing Entity would terminate funding for the propagation of the species and either fund propagation of an additional BDCP covered fish species or deobligate funds to this conservation measure and reallocate them to augment funding other conservation measures identified in coordination with the Fishery Agencies through the BDCP adaptive management process.

Problem statement: Populations of both delta and longfin smelt have dramatically declined recently (IEP 2008). Although a variety of stressors are suspected, there is not a clear understanding of why these populations have declined (IEP 2008). There is evidence that delta smelt continue to decline and that very low population size could result in an Allee effect causing an even more rapid decline of the species (Mueller-Solger 2007). As a result, the risk of extinction of delta smelt is hypothesized to be increasing. Longfin smelt abundance has followed a similar trend to delta smelt (IEP 2008).

Hypotheses: Artificial propagation and maintenance of refugial populations of delta and longfin smelt are hypothesized to:

- provide a safeguard against the possible extinction of delta and/or longfin smelt by maintaining a captive population that is genetically similar to the wild population (Carolsfeld 1997, Kowalski et al. 2006, Sorensen 1998, Sveinsson & Hara 1995, Turner & Osborne 2008, USFWS 1998, 2003, Hedgecock et al. 2000, Hedrick et al. 1995, Nobriga 2008, B. Clarke, pers. comm., Turner et al. 2007, Lande 1988),
- improve the knowledge base regarding threats to and management of delta and longfin smelt by increasing the ability to study the effects of various stressors on these species using hatchery-reared specimens, and
- increase population sizes of delta smelt (Purchase et al. 2007, Deblois & Leggett 1991, Lande 1988, Flagg et al. 2000, Carolsfeld 1997, Kowalski et al. 2006, Sorensen 1998, Sveinsson & Hara 1995, USFWS 1998, 2003, Richards et al. 2004, Nobriga 2008, B. Clarke, pers. comm.) and longfin smelt (Flagg et al. 2000, Carolsfeld 1997, Kowalski et al. 2006, Sorensen 1998, Sveinsson & Hara 1995, USFWS 1998, 2003, Richards et al. 2004, Nobriga 2008) to self-sustaining levels in the wild.

Adaptive Management Considerations: Based on review of U.S. Fish and Wildlife Service and UC Davis Fish Culture Lab performance and effectiveness monitoring, the BDCP Implementing Entity would coordinate with the U.S. Fish and Wildlife Service and/or the UC Davis Fish Culture Lab to adjust hatchery and/or refuge population management strategies and funding levels through the BDCP adaptive management process, as appropriate.

OSCM21: Screen, Remove, Relocate, Consolidate, Modify and/or Alter Timing of Non-Project Diversions to Reduce Entrainment of Covered Fish Species at within the Delta. The BDCP Implementing Entity will provide $___ over the term of the BDCP to reduce entrainment at non-project diversions. To implement this conservation measure, the BDCP Implementing Entity will take two actions:

1. Support the U.S. Bureau of Reclamation's Anadromous Fish Screen Program and DFG's Fish Screen and Passage Program to screen non-project diversions, thereby reducing entrainment risk of covered fish species at non-project diversions, at a funding level of $____ over the term of the BDCP[3]. Decisions regarding which diversions to prioritize in this element will rely on existing criteria established by these programs; and

2. In cooperation with willing non-project diverters, share costs for removing, relocating, consolidating, modifying design, and altering operations of individual non-project diversions, as appropriate, to reduce the risk of entrainment of covered fish species at a funding level of $____ over the term of the BDCP. Relocation and consolidation would involve moving diversions from high quality habitat for covered fish species to lower quality habitat.

   Decisions regarding which diversions to prioritize in this second element will rely in part on existing criteria established by the Anadromous Fish Screen Program and the Fish Screen and Passage Program. In addition, DFG is expected to conduct a comprehensive study to determine the distribution of fish in the Delta relative to non-project diversions and to determine entrainment rates of at least 27 diversions throughout the Delta (C. Armor pers. comm.). If DFG monitoring is not funded, the BDCP Implementing Entity will fund a similar study to gain this information to inform prioritization.

This conservation measure could employ either of two strategies. The first would focus on the largest diversions (greater than 250 cfs) under the assumption that larger diversions entrain fish at a disproportionately larger rate than smaller diversions. The second strategy would be to focus on the many smaller diversions, which are cheaper to screen per unit capacity. The relative benefit of these two approaches for covered species will be evaluated based on the results of the DFG study described above.

For the first element of this conservation measure, the BDCP Implementing Entity would enter into Memoranda of Agreements (MOAs) or similar binding instrument with the Bureau of Reclamation and DFG as described in Section 3.4.3.1.

For the second element of this conservation measure, the BDCP Implementing Entity would enter into contracts or similar binding instruments with non-project diverters that would describe respective roles and obligations for expenditure of BDCP funding. Elements of the contracts would include a description of specific actions that would be funded by BDCP, preparation and approval of project designs, BDCP funding levels, provisions for documenting work performed, access to conduct effectiveness monitoring, and provisions for modifying or terminating the contracts.

[3] With limited funds and the high cost of screening, both programs have been forced to prioritize diversions on which to install screens. The Bureau's program prioritizes based on size, location, number of species impacted, and cost, whereas DFG's program prioritizes screening of diversions based on the likelihood and level of impact on federal and state listed endangered species. To date, most screens have been installed on the largest diversions upstream of the Delta under the assumption that larger diversions entrain a disproportionately higher number of fish than smaller diversions, although there is some uncertainty regarding this assumption. Both programs have relied on internal and CALFED ERP funds and regularly partner with the Family Water Alliance, a non-profit organization that has acted as the program manager of the Sacramento River Small Diversion Fish Screen Program since 1996.

The conservation measure could include, but is not limited to, any of the following methods:

- Removal of individual diversions with large impacts on covered fish species,
- Consolidation of multiple diversions to a single or fewer diversions placed in lower quality habitat would reduce entrainment of covered fish species,
- Relocation of diversions with large effects on covered species from high quality to lower quality habitat[4],
- Relocation of diversions to areas of lower habitat quality,
- Reconfiguration of individual diversions in high quality habitat to take advantage of small scale distribution patterns and behavior of covered fish species relative to the location of individual diversions in the channel[5], and
- Alteration of the daily and seasonal timing of irrigation and therefore diversions. The practicability of this approach is dependent on the crop being grown, the season when irrigation is needed relative to season fish distribution patterns, and the diel activity patterns of the covered fish species in the area of the diversion[6].

Problem statement: There are approximately 2,200 water diversions within the Delta (Figure 2) and an additional 1,000 in place along the Sacramento and San Joaquin Rivers and their tributaries outside of the Delta and the Suisun Marsh (Herren and Kawasaki 2001). A coarse estimate of 22,000 cfs has been calculated as the total capacity of these diversions. The majority divert water to agricultural fields between April-August, depending on the crop. This diversion timing partially overlaps with the presence of many covered species in the Delta (generally January-July). Over 95% of these water diversions are not screened to reduce fish entrainment (Herren and Kawasaki 2001). Given this information, the potential for significant entrainment of fish is high (Hallock and Van Woert 1959 as cited Moyle and White 2002). Limited studies indicate that screens over such diversions have been at least 99% effective in reducing fish entrainment into them, even for larval fish <25 mm (Nobriga et al. 2004).

Hypotheses: The screening, removal, relocation, consolidation, modification and/or alteration in the timing of non-project diversions are hypothesized to:

- reduce entrainment mortality by non-project diversions of covered fish species, including larval and juvenile delta and longfin smelt (Cook and Buffaloe 1998, Nobriga et al. 2004),

[4] High quality habitat includes potential spawning areas, important migration pathways, or known centers of distribution. Low quality habitat includes back channels with limited connectivity to main Delta channels or areas that are close to other sources of stress.

[5] For example, if the diversion were located in an area with high abundance of sturgeon, the diversion should be off the bottom. If the diversion is located in an area of high Chinook salmon or splittail abundance, the diversion should be off shallow slopes. Other aspects that could be modified include proximity to non-native predator habitat and orientation, shape, and design of the distal end, or movement of the intake to a groundwater well location adjacent to the channel.

[6] The agricultural irrigation period in the Delta is generally between April and August, depending on the crop. The early part of this season coincides with the presence of juveniles of all nine covered fish species in the Delta. Combined with a comprehensive monitoring plan determining the spatio-temporal patterns on a real-time basis, diversion operations could be altered when covered species are in the vicinity of a diversion.

Many covered fish species appear to exhibit diel patterns of activity (Grimaldo 2006, Webb et al. 2006b, Wilder and Ingram 2006) that could be used to determine diel timing of diversion operations. The goal would be to divert when covered fish species are not near in-channel location of the diversion.

juvenile green (Cook and Buffaloe 1998, CDFG 2002, Nobriga et al. 2004) and white sturgeon (Cook and Buffaloe 1998, Nobriga et al. 2004, R. Garz, CDFG, pers. comm.), juvenile splittail (Young and Cech 1996, Sommer et al. 1997, 2007, Cook and Buffaloe 1998, Moyle et al. 2004, Nobriga et al. 2004, Matica and Nobriga 2005), and fry and juvenile Chinook salmon (all races) and steelhead (Cook and Buffaloe 1998, Nobriga et al. 2004); and

- increase food availability for delta and longfin smelt (Lund et al. 2007, 2008), green sturgeon (Nilo et al. 2006, Wanner et al. 2007,), white sturgeon (Brannon et al. 1984, Buddington and Christofferson 1985, Muir et al. 2000), splittail, Chinook salmon (all races), and steelhead through reduced entrainment of phytoplankton and zooplankton from the Delta.

Adaptive management considerations: The BDCP Implementing Entity may adjust its strategies for selecting diversions to be relocated or consolidated, modify intake designs, or adjust funding levels through the BDCP adaptive management process based on monitoring results and other relevant information (e.g., monitoring and research conducted by others). If results of monitoring indicate that screening of non-project diversions does not substantially and cost-effectively benefit covered fish species, the BDCP Implementing Entity in coordination with Fishery Agencies may terminate this conservation measure. If terminated, remaining funding would be deobligated from this conservation measure and reallocated to augment funding for other more effective conservation measures identified in coordination with the Fishery Agencies through the BDCP adaptive management process.