Fifth Draft
Other Stressors Conservation Measures
(May 1, 2009)

Note to Steering Committee: This handout presents the fifth draft of other stressors conservation measures (i.e., measures that address stressors to covered fish species that are not related to water operations and physical habitat restoration).This draft of other stressor conservation measures will be discussed at the May 8, 2009 Steering Committee Meeting.

This fifth draft reflects the outcomes of the April 3, 2009 Steering Committee meeting, Other Stressors Sub-Group meetings on January 29, 2009 and February 13, 2009, and correspondence with Co-Chairs of the Other Stressors Working Group. This draft includes preliminary language for monitoring and adaptive management for OSCM13, 16, 20, and 21 (monitoring and adaptive management text for the remaining OSCM's is in process). In an effort to make the conservation measures more hypothesis-driven, the fifth draft has been reformatted to include 'Problem Statement' and 'Hypotheses' sections for each conservation measure.

This draft also reflects extensive revisions in response to several recommendations from the Fishery Agencies. The Fishery Agencies have encourage the Workgroup to describe with greater specificity the actual undertaking of the implementing entity(ies) associated with each measure, the timeframe for the implementing of the measure, the capabilities of the implementing entity(ies) to undertake the described action and the anticipated benefits for the species or ecosystem that might ensue from it. This draft reflects those revisions.

The Workgroup recommends the inclusion of these measures into the draft conservation plan to reflect the comprehensive nature of the approach to conservation that underlies the BDCP, as described in the Overview of the Conservation Strategy dated January 19, 2009, the underlying BDCP Planning Agreement dated October 6, 2006, and as encouraged by the habitat conservation planning programs of the ESA and the NCCPA. The Workgroup recommends the inclusion of these conservation measures because they address multiple other stressors on the system (such as pollutant loadings and invasive species) that are widely acknowledged as compromising the productivity of the system and because they therefore may provide important benefits to ecosystem function and species conservation in the Delta. The Workgroup further recognizes that these measures may individually vary in the scope or significance of the conservation benefits that ultimately result from these efforts; nevertheless, they remain committed to them and open to other, similar measures to reflect their commitment to a comprehensive, multi-pronged approach to helping restore the ecological function of the Delta and the species which depend upon it. The status of other stressor conservation measures are summarized in the table below.

Summary Table of Other Stressor Conservation Measures

= Conservation measures recommended for deletion (confirmed by Steering Committee 4/3/09).

Conservation Measure Code	Type of Implemen-tation	Implementing Agency (Program)	Analyzed by DRERIP?	Status – Changes made in fifth draft

Conservation Measure Code	Type of Implemen-tation	Implementing Agency (Program)	Analyzed by DRERIP?	Status – Changes made in fifth draft
OSCM1 Ammonia/ um Reduction	Research, Then Possibly Funding	Individual wastewater treatment plants (WWTPs)	Yes	Updated CM text based on comments received and CALFED Ammonia/um Workshop. Made general to all WWTPs. Made table of all WWTPs that could affect covered species in Delta and Suisun Bay.
OSCM2 Endocrine Disrupter Reduction	Research, Then Possibly Funding	Individual WWTPs	Yes	Updated CM text based on comments received. Made table of all WWTPs that could affect covered species in Delta and Suisun Bay.
OSCM3 Methyl-Mercury Reduction	Direct Funding	CVRWQCB	Yes	Updated CM text with new information. Will review DRERIP results to help determine usefulness of measure to fish.
OSCM4 Pesticide/ Herbicide Reduction	Direct Funding	CVRWQCB	Yes	Updated CM text with new information. Need additional information from CVRWQCB
OSCM5 Urban & Stormwater Run-off	Direct Funding	Individual Urban and Stormwater Runoff Dischargers	Yes	Currently contacting local cities and counties as to actual funding shortfalls and specific programs that could be funded. Updated CM text with new information.
OSCM6 Toxic Spill Response	Direct Funding	DFG (Office of Spill Prevention and Response [OSPR])	No	Deleted CM as per April 3, 2009 Steering Committee Meeting
OSCM7 Deep Water Ship Channel –Low DO	Direct Funding	Port of Stockton, USACE	No	Revise text to focus on long-term O&M per 4/3/09 SC Meeting discussion.
OSCM8 Blackwater Discharge	Direct Funding	Local wetland managers	Yes	Deleted CM as per April 3, 2009 Steering Committee Meeting
OSCM9 Ballast Water/Hull Fouling	Research, Then Possibly Funding	US Coast Guard (Ballast Water Management Program); State Lands Commission (Ballast Water Program)	No	Deleted CM as per April 3, 2009 Steering Committee Meeting
OSCM10 Recreational Boat Inspection	Direct Funding	DFG, CDFA	No	Updated CM text with new information.
OSCM11 Invasives Rapid Response Team	Direct Funding	DFG (OSPR)	No	Revise text to include increased efforts to monitoring in addition to a rapid response program per 4/3/09 SC Meeting discussion.

Conservation Measure Code	Type of Implementation	Implementing Agency (Program)	Analyzed by DRERIP?	Status – Changes made in fifth draft
OSCM12 Zebra-Quagga Establishment Risk Reduction	Direct Funding	DFG and local agencies	No	Updated CM text with new information.
OSCM13 SAV/ FAV Removal	Direct Funding	Department of Boating and Waterways (Aquatic Pest Control)	Yes	Updated CM text with new information.
OSCM14 Non-Native Fishing Regulations	Regulatory	California Fish and Game Commission	Yes	Updated CM text with new information.
OSCM15 Control Predation of Salvaged Fish	Direct Funding	N/A	No	Deleted CM as per April 3, 2009 Steering Committee Meeting
OSCM16 Increase Enforcement on Illegal Harvest	Direct Funding	DFG (Delta-Bay Enhanced Enforcement Program)	Yes	Updated CM text with new information.
OSCM17 Splittail Harvest Regulations	Regulatory	California Fish and Game Commission	Yes	Updated CM text with new information.
OSCM18 Hatchery and Genetic Management Plans	Direct Funding	State and federal hatchery managers	No	In discussion with hatchery leads to determine specific needs from each hatchery. Updated CM text with new information.
OSCM19 Mass Marking Hatchery Salmon	Regulatory, Direct Funding	State and federal hatchery managers	Yes	Updated CM text with new information.
OSCM20 Smelt Hatchery	Direct Funding	UC Davis (Fish Culture Lab), USFWS	Yes	Updated CM text with new information.
OSCM21 Non-Project Diversions	Direct Funding	USBR, DFG	Yes	Updated CM text with new information.
OSCM22 No-Wake Zones In Restoration Areas	Regulatory, Direct Funding	Department of Boating and Waterways	No	Changed CM to specifically protect habitat restored by BDCP. Updated CM text with new information.

1

3.4.3 Other Stressors Conservation Measures

3.4.3.1 Overview

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

Many of these draft conservation measures address issues and activities that are not currently within the direct control of the BDCP member entities. Because they seek to address a wide range of activities and "stressors" with known or suspected adverse effects on covered species and their habitats, these measures are included here to reflect the BDCP's intention to embrace a comprehensive, broad based conservation strategy. These measures have been framed to establish reliable mechanisms to promote their execution and success by those entities with more direct responsibilities for these activities. Nevertheless, further work on these mechanisms is anticipated and encouraged as the planning process progresses.

3.4.3.2 Conservation Measures

OSCM1: Reduce the Load of Ammonia and Ammonium in Effluent Discharged from Wastewater Treatment Plants into the Delta and Suisun Bay, if Warranted Based on Research. In coordination with sanitation districts that discharge wastewater into waterways within the Delta and Suisun Bay (hereafter, "local sanitation districts"), evaluate the need and, if demonstrated to be necessary to protect covered fish species, reduce the levels of effluent-derived ammonia/um entering the Delta and Suisun Bay. The BDCP Implementing Entity would work closely with local sanitation districts in evaluating ongoing research and funding additional research to determine the effects of effluent-derived ammonia and ammonium ion on covered species. If scientific findings identify adverse effects on covered species, the BDCP and local sanitation districts would work together to determine the appropriate conservation measures to reduce the load of ammonia/um in the discharge to less than ____. The BDCP would assist local sanitation districts in identifying sources of funding for these conservation measures. The Central Valley Regional Water Quality Control Board (CVRWQCB) would be included in the design and evaluation of these studies and comment on any measures that are proposed to be implemented to address ammonia/um discharges from the treatment plants.

The BDCP Implementing Entity, Fishery Agencies, and local sanitation districts will review current research on whether or not the discharges of ammonia/um effluent from local sanitation districts have adverse direct or indirect effects on covered fish species. If additional research is warranted, the BDCP Implementing Entity, in coordination with Fishery Agencies, CVRWQCB, and local sanitation districts, would identify additional research needs and funding sources to evaluate the types and levels of effects of discharged ammonia/um effluent on covered fish species. The BDCP Implementing Entity would enter into Memoranda of Agreement (MOA) or similar binding instruments with local sanitation districts that would describe respective roles and obligations for funding and conducting any additional research identified through the process described above. Elements of the MOA would include:

- a description of specific activities that would be funded by BDCP;
- preparation of annual research work plans for BDCP funded activities;
- provisions for documenting work performed; and

- provisions for modifying or terminating MOAs.

If research results indicate that discharges of ammonia/um effluent from local sanitation districts have adverse effects on covered fish species, the BDCP Implementing Entity would work with each local sanitation district and appropriate state and federal entities to identify sources of funding to develop and implement actions that would eliminate or minimize adverse effects of the effluent on covered fish species. If research results indicate that discharges of ammonia/um effluent from local sanitation districts do not adversely affect covered fish species, the BDCP would not work with local sanitation districts to develop conservation measures. If actions to address the discharge of ammonia/um effluent are implemented, the BDCP Implementing Entity would work with local sanitation districts in reviewing covered fish species-response monitoring to assess the effectiveness of actions to eliminate or minimize effects of ammonia/um on covered fish species.

Problem statement: Ammonia (NH_3) and ammonium (NH_4^+) are common constituents of effluent from wastewater treatment plants having only primary and secondary treatment processes (Jassby 2008). There are 23 wastewater treatment plants that discharge their effluent in or just upstream of the Delta and Suisun Bay (Table 3.1). Of these, 12 employ only primary and secondary treatments, currently releasing on average approximately 285 million gallons of effluent into the Delta and Suisun Bay waterways each day. The largest wastewater treatment plant in the Delta, the SRCSD Wastewater Treatment Plant, released an average of 158 million gallons of treated effluent into the Delta per day during 2001-2005 (Jassby 2008). The SRCSD Wastewater Treatment Plant and other treatment plants employ primary and secondary treatment processes to meet current waste discharge specifications in its existing NPDES permit, which is protective of beneficial uses and currently meets the US EPA aquatic criteria for ammonia/um. However, secondary treatment processes may not remove levels of ammonia/um and/or other toxic compounds to levels below which they affect fish. Advanced treatment processes can be up to 90% efficient at reducing ammonia/um loads in effluent (Wallace et al. 2006, Chan et al. 2008).

Hypotheses: *[Note: Because this conservation measure is contingent upon a necessary research component, it is not possible to identify clear hypothesized benefits of the conservation measure. Instead, a summary of potential effects of ammonia/um to covered fish species in the context of proposed research topics are described here.]*

Ammonia/um may affect covered fish species both directly and indirectly. Directly, ammonia/um can be toxic to fish at elevated concentrations (Randall and Tsui 2002), although concentrations currently measured in the Delta are well below levels at which the U.S. EPA considers to be acutely or chronically toxic (SWRCB 2008). For example, SRCSD has conducted multiple modeling and experimental efforts and concluded that the residual impacts of ammonia/um in their effluent on aquatic organisms are "less than significant" (SRCSD 2003). However, concentrations in the Delta are above levels that have been shown to cause sublethal effects in sensitive fish species (USEPA 1999). In addition, fish may be considerably more sensitive than USEPA aquatic criteria indicate when they are exposed to ammonia/um in combination with other stressors including elevated temperature, food limitations, and other contaminants (Eddy 2005). Ammonia and ammonium exist in equilibrium in water according to the equation: $NH_4^+ \leftrightarrow NH_3 + H^+$. Ammonia is more acutely toxic to fish and invertebrates than ammonium. High concentrations of ammonia in water reduce or

Table 3.2. The following table lists wastewater treatment plants (WWTPs) that discharge treated wastewater into Delta and Suisun Bay waterways and could, therefore, affect BDCP covered fish species and natural communities. These WWTPs are sorted by level of treatment and capacity. Much of this information was extracted from the 2006 California State Water Project's Watershed Sanitary Survey. Some information has changed since that time. Wastewater treatment plants/facilities located at a site beyond potential ammonia- (and derivatives) laden receiving waters affecting BDCP covered fish species and natural communities are not included. mgd = million gallons per day

Wastewater Treatment Plant	Receiving Water Location	Level of Treatment	Capacity	Source	Comments
Sacramento Regional County Sanitation District	Sacramento River near	Secondary	158 mgd of treated effluent during 2001-2005	Jassby 2008	Plans to expand in the future.
Central Contra Costa Sanitary District	Suisun Bay 38° 2' 44" N 122° 5' 55" W	Secondary	Annual average flow: 42.2 mgd Permitted average dry weather flow: 53.8 mgd	ORDER NO. R2-2003-0072 NPDES PERMIT NO. CA0038024	445,000 residents in Alamo, Danville, parts of Dublin, Lafayette, parts of Martinez, Moraga, Orinda, Pleasant Hill, San Ramon and Walnut Creek; it also treats the wastewater from Concord and Clayton.
Vallejo Sanitation and Flood Control District Wastewater Treatment Plant	Carquinez Strait 38º 3' 53" N 122º 13' 42" W Mare Island Strait 38º 5' 23" N 122º 15' 12" W	Secondary	15.5 mgd permitted average dry weather flow; 12.3 mgd daily average flow 2003-2005	ORDER NO. R2-2006-0056 NPDES PERMIT NO. CA0037699	Population served: 117,000
Tracy Wastewater Treatment Plant	Old River	Secondary	7.1 mgd, but had planned to expand to 10.8 mgd	Sanitary Survey	Plans to expand in the future
Vacaville Easterly Wastewater Treatment Plant	Old Alamo Creek to Alamo Creek, to Cache Slough, to Sacramento River	Secondary	6.9 mgd	Sanitary Survey	Plans to expand in the future
Delta Diablo Sanitation District	New York Slough, to San Joaquin River 38° 01' 40"N 121° 50' 14" W	6.7 mgd secondary only; 7.5 mgd tertiary and recycled	14.2 mgd, but permitted flow 16.5 mgd average annual flow	NPDES Permit No. CA0038547 Order No. R2-2003-0114	Services Antioch & Pittsburg Population served 180,000 in 2003 Planned expansion to 22.7 mgd by 2015

Wastewater Treatment Plant	Receiving Water Location	Level of Treatment	Capacity	Source	Comments
Manteca Wastewater Quality Control Facility	San Joaquin River	Secondary	5.72 mgd (monthly average)	Sanitary Survey	Services Manteca & Lathrop Currently 2 mgd is applied to land and the rest is discharged to the San Joaquin River
City of West Sacramento	Sacramento River	Secondary	5.5 mgd	City of West Sacramento Website	
City of Davis	Willow Slough or Restoration wetlands, and then to Conaway Ranch Toe Drain	Secondary	Permitted for 7.5 mgd, but 2000-2004 average was 5.4 mgd	City of Davis Website	
City of Benicia Wastewater Treatment Plant	Carquinez Strait 38º 02’ 30” N 122º 09’ 03” W	Secondary	Permitted average dry weather flow 4.5 mgd; daily average flow 2001-2005: 2.96 mgd	ORDER NO. R2-2008-0014 NPDES PERMIT NO. CA0038091	
Discovery Bay Wastewater Treatment Facility	Old River	Secondary	1.1 mgd	Sanitary Survey	
Port Costa Wastewater Treatment Plant	Carquinez Strait 38º 02’ 55” N 122º 10’ 56” W	Secondary	0.033 mgd permitted average dry weather flow; 0.02 mgd daily average flow 2003-2007	ORDER NO. R2-2008-0005 NPDES PERMIT NO. CA0037885	
City of Stockton Wastewater Treatment Plant	San Joaquin River	Tertiary	Over 30 mgd	City of Stockton Website	Biotowers used to reduce ammonia/um
Fairfield-Suisun Sewer District	Boynton Slough outfall in Suisun Marsh 38° 12' 33" N 122° 03' 24" W	Tertiary	Annual average flow 2000-2002: 16.1 mgd; permitted average dry weather flow 17.5 mgd	ORDER NO. R2-2003-0072 NPDES PERMIT NO. CA0038024	Population served in 2003: 130,000. Plans to expand to 21.5 mgd
Mountain House Community Services District Wastewater Treatment Facility	Old River, 3 miles west of Tracy	Tertiary	13 mgd	Sanitary Survey	Plans to expand in the future

Wastewater Treatment Plant	Receiving Water Location	Level of Treatment	Capacity	Source	Comments
Dry Creek Wastewater Treatment Plant	Dry Creek tributary to Sacramento River	Tertiary	6.5 mgd	Sanitary Survey	Services Roseville and unincorporated areas of Placer County
Woodland Water Pollution Control Facility	Tule Canal, tributary to Yolo Bypass	Tertiary	6 mgd	Sanitary Survey	Plans to expand in the future
Lodi – White Slough Pollution Control Plant	Dredger Cut, tributary to White Slough – Sept-May	Tertiary	5.9 mgd	Sanitary Survey	Plans to expand in the future
American Canyon Wastewater Treatment Facility	North Slough 38º 11' 03.7" N 122º 16' 39.0" W Constructed freshwater wetlands 38º 11' 05.7" N 122º 16' 44.8" W	Tertiary	Permitted average dry weather flow 2.5 mgd	ORDER NO. R2-2006-0036 NPDES PERMIT NO. CA0038768	
Lincoln Wastewater Treatment and Reclamation Facility	Auburn Ravine, tributary to Sacramento River	Tertiary	2.4 mgd	Sanitary Survey	Plans to expand in the future
Brentwood Wastewater Treatment Plant	Marsh Creek, tributary to Dutch Slough	Tertiary	2.2 mgd	Sanitary Survey	
University of California Davis Wastewater Treatment Plant	South and North Forks of Putah Creek, tributary to Yolo Bypass	Tertiary	1.5 mgd (monthly average dry weather)	Sanitary Survey	Plans to expand in the future
Auburn Wastewater Treatment Plant	Auburn Ravine, tributary to Sacramento River	Tertiary	1.34 mgd (average daily flow)	Sanitary Survey	

1

reverse diffusive gradients and cause a buildup of ammonia on the gills of fish and invertebrates, which, under normal ambient conditions, act to diffuse endogenously-produced ammonia (US EPA 1999). Ammonium is also toxic to fish and invertebrates under certain conditions. As a result, the 1999 US EPA criteria for ammonia/um concentrations were established in terms of total ammonia (NH_3+NH_4^+). The ammonia/um equilibrium and, therefore, the toxicity of ammonia/um, depend heavily on pH (Warren 1964) and temperature (US EPA 1999); when pH is higher or temperature is lower, ammonia/um toxicity is greater. The effect of pH on toxicity is higher than that of temperature. The ionic composition of water can also be a determinant of toxicity, but these effects are poorly understood and, therefore, were not included in the1999 EPA criteria. Toxicity varies by species. Fathead minnows are used by the SRCSD and other dischargers in accordance with their NPDES permits due to their high sensitivity to ammonia/um. However, delta smelt and salmonids can be >5 times more sensitive to ammonia/um than fathead minnows (Werner et al. 2009). Werner et al. (2008b) found that water samples near the Sacramento WWTP effluent reduced 4-day larval delta smelt survival in 2006, but did not affect survival even after 7 days in 2007, and concentrations of ammonia/um in water samples were below US EPA effect concentrations (e.g., LC_{50}). A comprehensive monitoring and research plan is needed to determine acute and chronic toxicity to all covered fish species of ammonia/um and other constituents in the water column.

Ammonia/um can indirectly affect covered fish species by disrupting the food web via at least three mechanisms. First, elevated concentrations of ammonium ion can disrupt the uptake of nitrate (NO_3^-) by phytoplankton, leading to suppression of plant growth (Conway 1977, Cochlan and Harrison 1991). Phytoplankton form the base of the food web from which much of the food energy for the Delta ecosystem is derived (Jassby and Cloern 2000). The phytoplankton community in the Delta and Suisun Bay has shifted over the past few decades from dominated by diatoms to dominated by green algae, blue-green algae (cyanobacteria), and flagellates (Lehman 2000). Diatoms are larger phytoplankton with higher growth rates that thrive in high nitrate conditions in San Francisco Bay (Wilkerson et al. 2006) and are believed to be an important pathway of productivity to higher levels of the higher food web. As a result, a reduction in diatoms could lead to lower zooplankton abundance or a shift in zooplankton community composition, although changes in productivity could be masked by concomitant changes in Corbula grazing. Decreased zooplankton abundance could lead to a lower food base for covered pelagic fish species, particularly delta and longfin smelt. The suppression of nitrate uptake by ammonium has been demonstrated previously in diatoms in oceanic waters (Dugdale and MacIsaac 1971, Dugdale and Hopkins 1978, Dugdale et al. 2006) and recently in San Francisco, San Pablo, and Suisun Bays during spring months (Wilkerson et al. 2006, Dugdale et al. 2007) and current studies are evaluating whether ammonium, in combination with other unknown factors, inhibits the uptake of nitrate by phytoplankton in the Delta (Dugdale 2008, Parker and Dugdale 2008). Pilot studies in 2007 and 2008 in the lower Sacramento and San Joaquin Rivers found suppression of phytoplankton growth (Ballard et al. 2009). However, preliminary tests in 2008 using Sacramento River water from River Mile 44 to Isleton did not find suppressed uptake of nitrate in phytoplankton despite high ammonium concentrations, although nitrate concentrations were low during the testing period (Parker and Dugdale 2008). More research is needed to determine whether and to what extent ammonium-driven suppression of diatom nitrate uptake and growth is occurring in the Delta.

Second, ammonia/um may have toxic effects to invertebrates that are prey items for covered fish species that are similar to those that fish may experience. If food is limiting to delta and/or longfin smelt, a reduction in the abundance of prey could reduce the abundance of these fish species. *Hyalella azteca*, a resident amphipod in the Delta, was the most sensitive invertebrate species to ammonia/um evaluated for the 1999 US EPA criteria. However, aside from a family of mussels that are not found in the San Francisco Estuary, invertebrates are generally less sensitive to ammonia/um than fish. A recent pilot study suggests that, in combination with other chemicals (i.e., pesticides), ammonia at elevated levels may reduce the survival of prey species for delta smelt and longfin smelt, *Eurytemora affinis,* although no conclusive evidence was found to support this (Teh et al. 2008). Further, Werner et al. (2008b) found that *Hyalella azteca* growth was correlated with ammonia/um at some, but not all, Delta stations. Clearly, more research is needed to determine whether this mechanism may be occurring in the Delta and Suisun Bay.

Third, high concentrations of ammonium ion may promote blooms of harmful cyanobacteria, *Microcystis aeruginosa*, which produce microcystins that are toxic to other aquatic organisms. High ammonium concentrations relative to phosphorus concentrations have been promote cyanobacteria blooms in other parts of the world (Michigan lakes: Ward & Wetzel 1980; Sweden: Gahnström et al. 1993). However, Lehman (2008) found that Microcystis cell density in the Delta correlated best with low flows and high water temperature and secondarily with nutrient concentrations and ratios. Further, Lehman (2008) indicated that Microcystis bloom she documented in 2004 "probably did not cause acute toxicity to aquatic food web organisms in the San Francisco Estuary" (p. 201), although no conclusive evidence was found to support this. Because microcystins were found in low concentrations in Corbula tissue, Lehman (2008) suggested that the clam may have the ability to selectively reject Microcystis colonies during feeding, similar to zebra mussels in the Great Lakes (Vanderploeg et al. 2001). If true, Corbula may release Microcystis from competition with other phytoplankton that Corbula eats. Further research is needed to verify or reject these potential mechanisms that could negatively affect covered fish species.

Implementation timeframe: It is anticipated that this conservation measure could be implemented in the BDCP near-term implementation period.

Implementation considerations: The potentially significant costs associated with improving wastewater treatment facilities could affect the practicability of implementing this conservation measure.

Resiliency to future changes: This action would not be influenced by future climate change.

Uncertainties/risks: A major uncertainty associated with this conservation measure is the extent to which ammonia/um has adverse effects on covered fish species at ambient concentrations in the Delta and Suisun Bay. Multiple research projects focused on the effects of ammonia/um to aquatic organisms being conducted over the next few years (SWRCB 2008) should address this uncertainty.

Monitoring and adaptive management considerations: ***[Note to reviewers:*** *this section is a general summary; more detail will be provided in future iterations.]* If effluent-derived ammonia and ammonium ion are found to have adverse effects on covered fish species, the BDCP Implementing Entity would coordinate with local sanitation districts needing modification to develop adaptive management and monitoring plans for assessing effectiveness of the proposed conservation measures. The adaptive management plan would identify the range of adaptive

management responses appropriate to proposed ammonia/um-reduction conservation measures and the process for adaptively adjusting implementation based on monitoring results. The types of monitoring that may be appropriate include:

- monitoring of ammonia/um in influent and effluent at treatment facilities;
- in-laboratory exposure of delta smelt and, as appropriate, other aquatic species to effluent samples to assess acute and chronic lethality; and
- monitoring of ammonium-mediated nitrate uptake inhibition in diatoms.

If results of monitoring of ammonia/um effects on the covered fish species and their food base indicate that ammonia/um reduction efforts have not been sufficient to significantly reduce adverse effects, treatment actions would be modified to be more effective through the adaptive management process. This effort would not substitute for any of the requirements prescribed by the CVRWQCB through permits or other regulatory authorities.

Reversibility: Should new facilities be constructed to address the effects of ammonia/um on covered species, the high cost and permanence of the wastewater treatment infrastructure would make the reversibility of such actions low.

OSCM2: Reduce the Load of Endocrine Disrupting Compounds in Effluent Discharged from Wastewater Treatment Plants into Delta Waterways if Warranted Based on Research. In coordination with sanitation districts that discharge wastewater into waterways within the Delta and Suisun Bay (hereafter, "local sanitation districts"), evaluate the need and, if demonstrated to be necessary to protect covered fish species, improve treatment processes at wastewater treatment facilities to reduce loads of endocrine disrupting compounds (EDCs) into the Delta and Suisun Bay. The BDCP Implementing Entity would work closely with local sanitation districts in evaluating ongoing research and funding additional research to determine the effects of effluent-derived EDCs on covered species. If scientific findings identify adverse effects on covered species, the BDCP and local sanitation districts would work together to determine the appropriate conservation measures to reduce the load of EDCs in the discharge to less than ____. The BDCP would assist local sanitation districts in identifying sources of funding for these conservation measures. The CVRWQCB would be included in the design and evaluation of these studies and comment on any measures that are proposed to be implemented to address discharges of EDCs from treatment plants.

The BDCP Implementing Entity, Fishery Agencies, and local sanitation districts will review current research on whether or not the discharges of EDCs from local sanitation districts have adverse direct or indirect effects on covered fish species. If additional research is warranted, the BDCP Implementing Entity, in coordination with Fishery Agencies, CVRWQCB, and local sanitation districts, would develop additional research needs and funding sources to evaluate the types and levels of effects of discharged EDCs on covered fish species. The BDCP Implementing Entity would enter into Memoranda of Agreement (MOAs) or similar binding instruments with local sanitation districts that would describe respective roles and obligations for funding and conducting any additional research identified through the process described above. Elements of the MOAs would include:

- a description of specific activities that would be funded by BDCP;
- preparation of annual research work plans for BDCP funded activities;
- provisions for documenting work performed; and

- provisions for modifying or terminating the MOAs.

If research results indicate that discharges of EDCs from local sanitation districts have adverse effects on covered fish species, the BDCP Implementing Entity would work jointly with each local sanitation district and appropriate state and federal entities to identify sources of funding to develop and implement actions that would eliminate or minimize adverse effects of EDCs on covered fish species. If research results indicate that discharges of EDC effluent from local sanitation districts do not adversely affect covered fish species, the BDCO would not work with local sanitation districts to develop conservation measures. If actions to address the discharge of EDCs are implemented, the BDCP Implementing Entity would also work jointly with local sanitation districts in reviewing covered fish species-response monitoring to assess the effectiveness of actions to eliminate or minimize the effects of EDCs on covered fish species.

Problem statement: Endocrine disrupting compounds are exogenous substances that can interfere with or eliminate natural endogenous hormones in body (Kavlock et al. 1996). There are currently no criteria defined by the US EPA for discharges of EDCs, although work is currently occurring to establish a set of policies for initial screening of endocrine disrupting compounds (72 FR 70842).

Wastewater treatment plants can be large sources of EDCs (Sumpter and Jobling 1995, Chambers and Leiker 2006, Barber et al. 2007). There are 23 wastewater treatment plants that discharge their effluent in or just upstream of the Delta and Suisun Bay (Table 3.1). Of these, 12 employ only primary and secondary treatments, currently releasing on average approximately 285 million gallons of effluent into the Delta and Suisun Bay waterways each day. These treatment processes may not be sufficient to remove EDCs to levels below which they affect fish (Huang and Sedlak 2001, Campbell et al. 2006). Advanced treatment facilities have been shown to reduce EDCs by 30-85%, but reduction levels vary widely by specific EDC (Hemming et al. 2004, Drewes et al. 2005, Gray and Sedlak 2005).

Because natural endogenous endocrine chemicals (hormones) occur in extremely low concentrations in fish, it is thought that extremely low concentrations of exogenous endocrine disruptors could affect fish; however, the potency of exogenous EDCs is typically orders of magnitude lower than endogenous endocrines (Pait and Nelson 2002).

Hypotheses: *[Note: Because this conservation measure is contingent upon a necessary research component, it is not possible to identify clear hypothesized benefits of the conservation measure. Instead, a summary of potential effects of EDCs to covered fish species in the context of proposed research topics are described here.]*

Endocrine disruption has been observed in fish exposed to wastewater effluents throughout the world (Sumpter and Jobling 1995, Jobling et al. 1998, Pait and Nelson 2002, Chambers and Leiker 2006, Barber et al. 2007, Kidd et al. 2007). Because EDCs interfere or eliminate hormones receptors in fish, they may have significant effects on the development and health of fish, as well as on the ability of fish to reproduce successfully and have their progeny survive to reproduction (Pait and Nelson 2002, Falconer et al. 2006). Examples of effects of EDCs on fish include intersex fish (gonadal characteristics of both males and females, or "ovatestes") (Jobling et al. 1998), inhibition of gonadal growth and development (Jobling et al 1996), degeneration of gonadal tissue (Lye et al. 1998); presence of the egg yolk precursor, vitellogenin, in male fish (Panter et al. 1998), and behavioral modifications associated with reproductive competency (Barber et al 2007). Kidd et al. (2007) demonstrated that levels of synthetic estrogen similar to

those found downstream of wastewater treatment plant discharges can cause a population level crash in exposed fish. In Central Valley stream sampling, up to 38% of male fall-run Chinook salmon showed signs of endocrine disruption in the form of sex reversal (Williamson and May 2002), although this finding may have been an artifact of the test method rather than a true sex reversal of the fish (Williamson and May 2005). Riordan and Adam (2008) found endocrine disruption in male fathead minnows following in-situ exposures below the Sacramento wastewater treatment plant. A high level of incidence (100%) of vitellogenin was found recently in male splittail in Suisun Slough and its tributaries (C. Johnson pers. comm.). In 2005, a low level (6%) of adult delta smelt males showed evidence of endocrine disruption (Bennett et al. 2008), although the identity and source of the EDCs causing this effect are not known. While population level effects to fish are possible following low level exposures (Kidd et al. 2007), there are few data on ambient levels of EDCs in the Delta. In addition, effects are often observed at levels at or below the detection level for many of the EDCs (Huang and Sedlack 2001). Overall, there is a paucity of data specific to the Delta indicating whether or not EDCs have adverse effects to covered fish species.

Implementation timeframe: It is anticipated that this conservation measure could be implemented in the BDCP near-term implementation period.

Implementation considerations: The potentially significant costs associated with improving wastewater treatment facilities could affect the practicability of implementing this conservation measure. Actions could prove inadequate if reductions in fish risk levels are not achievable by wastewater treatment alone.

Resiliency to future changes: This action is not expected to be influenced by future climate change.

Uncertainties/risks: A major uncertainty associated with this conservation measure is the extent to which EDCs have adverse effects on covered fish species at ambient concentrations in the Delta. This uncertainty is not unique to covered fish species in the Delta; the effects on species in other aquatic systems is also largely uncertain (Pait and Nelson 2002)

Monitoring and adaptive management considerations: *[**Note to reviewers:** this section is a general summary; more detail will be provided in future iterations.]* If EDCs are found to have adverse effects on covered fish species, the BDCP Implementing Entity would coordinate with local sanitation districts needing modification to develop adaptive management and monitoring plans for assessing effectiveness of the proposed conservation measures. Adaptive management plans would identify the range of adaptive management responses appropriate to proposed EDC-reduction conservation measures and the process for adaptively adjusting implementation based on monitoring results. The types of monitoring that may be appropriate include monitoring of influent and effluent for EDCs and field sampling and evaluations of endocrine and reproductive systems of covered fish species to assess the effectiveness of conservation measures in reducing EDC effects. If monitoring results indicate that EDC reduction efforts have not been sufficient to significantly reduce adverse affects, treatment actions would be modified to be more effective through the adaptive management process. This effort would not substitute for any of the requirements prescribed by the CVRWQCB through permits or other regulatory authorities.

Reversibility: Should new facilities be constructed to address the effects of EDCs on covered species, the high cost and permanence of the wastewater treatment infrastructure would make the reversibility of such actions low.

OSCM3: Reduce the Load of Methylmercury Entering Delta Waterways. Support the Central Valley Regional Water Quality Control Board's (CVRWQCB) Draft Total Maximum Daily Load (TMDL) to reduce the load of methylmercury entering the Delta and in-Delta sources by __ percent from 200_ levels at a funding level of $____ over the term of the BDCP. The conservation measure could support staff salaries and/or fund specific actions to reduce these sources (e.g., Cache Creek Settling Basin efficiency improvements). Four primary actions could be supported:

1. modify the Cache Creek settling basin to improve mercury and sediment trapping efficiency;
2. remediate inorganic mercury sources upstream of the Delta, including mercury contaminated sediment "hot spots" in stream channels and mercury and gold mines;
3. avoid or minimize transport of loads of methylmercury entering the Delta from floodplain and intertidal marsh restoration actions by the BDCP; and
4. work with CVRWQCB to identify best management practices for other sources of methylmercury.

The BDCP Implementing Entity would enter into a Memorandum of Agreement (MOA) or similar binding instrument with the CVRWQCB that would describe respective roles and obligations for expenditure of BDCP funding. Elements of the MOA would include a description of specific activities that would be funded by BDCP, preparation of annual work plans for BDCP funded activities, provisions for documenting work performed, monitoring responsibilities, and provisions for modifying or terminating the MOA.

The BDCP Implementing Entity, in coordination with Fishery Agencies, would be responsible for developing annual work plans that specify the extent of mercury reduction activities to be implemented by the CVRWQCB at funded levels. The CVRWQCB would be responsible for implementing the scope of work and submitting reports as specified in the MOA that demonstrate that the work plan has been successfully implemented. The CVRWQCB would also be responsible for monitoring the effectiveness of mercury reduction measures and adjusting control methods to improve their effectiveness over time.

The BDCP Implementing Entity would be responsible for monitoring the effectiveness of mercury reduction activities in achieving covered fish species benefits. This monitoring would be required because of the uncertainties surrounding the population level benefits of reducing mercury loads on covered fish species (see *Uncertainties/Risks* discussion below).

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 and cost-effectively benefit covered fish species, the BDCP Implementing Entity, in coordination with Fishery Agencies, may terminate this conservation measure. The BDCP Implementing Entity, in coordination with the Fishery Agencies, would also terminate this conservation measure if the CVRWQCB chooses not to enter into a MOA with the BDCP Implementing Entity. 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.

Problem statement: The Central Valley Regional Water Quality Control Board recently 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.

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), 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 human exposure to mercury. The major concern of mercury involves human health. 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/).

Implementation timeframe: It is anticipated that implementation of this conservation measure could begin in the BDCP near-term implementation period. Timing of some actions would be dependent on the timing of other actions (e.g., floodplain and tidal marsh restoration).

Implementation considerations: Many of the upstream "hot spot" sites are Superfund sites and tied up in legal, funding, and logistical issues. There could be significant costs associated with this conservation measure for improved treatment facilities. Operation of settling basins (i.e., periodic removal of mercury-laden sediment) would need to occur in perpetuity. Much of this conservation measure is dependent on the Final TMDL.

Resiliency to future changes: This conservation measure is moderately resilient to future climate change, although the location of floodplain and tidal marsh and timing of floodplain inundation are expected to change with climate change.

Uncertainties/risks: Mercury has known adverse effects to humans and wildlife, can bioaccumulate in fish tissue, and can have sublethal physiological effects to some species (see Alpers et al. 2008). However, there is limited evidence that mercury causes direct mortality or has significant population level effects on BDCP covered fish species. Therefore, the magnitude of a population-level effect on covered species of this conservation measure may be low with low certainty and is dependent on research to determine whether there are population-level effects.

Monitoring and adaptive management considerations: *[**Note to reviewers:** this section is a general summary; more detail will be provided in future iterations.]* The CVRWQCB would be responsible for conducting monitoring necessary to assess the effectiveness of BDCP supported mercury reduction projects. The BDCP Implementing Entity will provide ongoing review of CVRWQCB monitoring, progress, and other relevant reports to assess the effectiveness of supported projects for reducing mercury loads entering the Delta and providing beneficial to covered fish species. The BDCP Implementing Entity will coordinate with the CVRWQCB to adjust mercury reduction strategies and funding levels through the BDCP adaptive management process as appropriate based on review of CVRWQCB monitoring and other reports.

Reversibility: Due to the high costs and additional infrastructure associated with implementation, this conservation measure is expected have a low reversibility.

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. To implement this conservation measure, the BDCP Implementing Entity would develop two tasks:

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 to levels at which they are not toxic to covered fish species (by __ percent from 200_ levels) 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 the waiver must be conditional, must be enforceable, and must contain monitoring to ensure compliance with these conditions. Dischargers must either join an established coalition group or proceed as an individual discharger. Coalitions 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 support, and encouragement of voluntary actions; and

2. Work with groups of farmers or large individual farmers and with reclamation districts and irrigation/drainage districts to develop voluntary agricultural chemical management plans to reduce the amounts of pesticides and herbicides reaching Delta waterways. Plans could include funding conservation easements, cost-sharing programs, and working with farmers and irrigation districts to:

    - Change pesticides and herbicides used to less toxic compounds to aquatic species and provide education on proper use;
    - Reduce amounts of pesticides and herbicides used through more direct application methods or implementation of integrated pest management techniques;
    - Reduce concentrations of pesticides and herbicides in return flows to Delta waterways through specific management practices;

- minimize environmental and human health risks by employing integrated pest management techniques;
- Reduce return flows from agricultural fields to the Delta by using water-efficient technologies (e.g., drip irrigation) (K. Fisher pers. comm.); and
- Reduce wind drift of pesticides and herbicides into Delta waterways.

To accomplish Task 1, the BDCP Implementing Entity would enter into a Memorandum of Agreement (MOA) or similar binding instrument with the CVRWQCB that would describe respective roles and obligations for expenditure of BDCP funding. Elements of the MOA would include a description of specific activities that would be funded by BDCP, preparation of annual work plans for BDCP funded activities, provisions for documenting work performed, monitoring responsibilities, and provisions for modifying or terminating the MOA.

The BDCP Implementing Entity would be responsible for developing annual work plans in coordination with Fishery Agencies that specify the extent of agricultural contaminant reduction activities to be implemented by the CVRWQCB at funded levels. The CVRWQCB would be responsible for implementing the scope of work and submitting reports as specified in the MOA that demonstrate that the work plan has been successfully implemented. The CVRWQCB would also be responsible for monitoring the effectiveness of agricultural contaminant reduction measures and adjusting reduction methods to improve their effectiveness over time.

The BDCP Implementing Entity would be responsible for monitoring the effectiveness of agricultural contaminant reduction activities in achieving covered fish species benefits. This monitoring would be required because of the uncertainties surrounding the population level benefits of reducing loads of agricultural pesticides and herbicides on covered fish species (see *Uncertainties/Risks* discussion below). The BDCP Implementing Entity in coordination with the Fishery Agencies may discontinue monitoring in future years if monitoring results indicate a strong correlation between reduction in agricultural pesticides and herbicides entering the Delta and responses of covered fish species.

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 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 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. The BDCP Implementing Entity, in coordination with the Fishery Agencies, would also terminate this conservation measure if the CVRWQCB chooses not to enter into a MOA with the BDCP Implementing Entity. 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.

To accomplish Task 2, the BDCP Implementing Entity would enter into binding agreements (e.g., conservation easements, contracts) with participating farmers and irrigation districts that would specify specific actions that would 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 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 would 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 would 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. The BDCP Implementing Entity, in coordination with the Fishery Agencies, may discontinue monitoring 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.

To address uncertainties related to the effectiveness of reducing pesticide and herbicide loads in achieving population-level benefits for covered fish species (see *Uncertainties/Risks* discussion below), the BDCP Implementing Entity, in coordination with the Fishery Agencies, will periodically review relevant research to determine if reducing pesticides and herbicides has been shown to provide direct or indirect benefits to covered fish species. If 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.

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, the use of metals such as copper have been used in the past 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 by:

- reducing direct mortality of splittail, delta and longfin smelt, green and white sturgeon, steelhead, and Chinook salmon (all races). A 2008 NMFS BO concerning pesticides indicated that reregistration 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. Saiki et al. (1992) found that undiluted agricultural drainwater from the San Joaquin River watershed was acutely toxic to juvenile Chinook salmon;
- 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). 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; and

- increasing food abundance for splittail, delta and longfin smelt, green and white sturgeon, steelhead, and Chinook salmon (all races). 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 covered fish species 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.

Implementation timeframe: It is anticipated that this conservation measure could be implemented in the BDCP near-term implementation period.

Implementation considerations: Working in coordination with willing farmers will be key to the success conservation measure. The Irrigated Lands Regulatory Program is expected to be updated in 2011. Therefore, the efficacy of Task 1 in the conservation measure may need re-evaluation at that time. For Task 2, it will be difficult to determine the extent of benefits until the level of participation has been identified. Substitution of one pesticide or herbicide could lead to its own set of problems, such as the switch from organophosphates to pyrethroids.

Resiliency to future changes: If sea level rise or other market factors make farming in the Delta impractical in the future, this action may be deemed unnecessary.

Uncertainties/risks: The effect of pesticides on covered fish species at a population level is not well known (Werner and Oram 2008). There is much evidence that pyrethroids have sublethal effects on fish species (e.g., Weston et al. 2004) and even more evidence that pyrethroids have direct acute impacts on invertebrates, which could serve as prey species for covered fish species (Van Wijngaarden et al. 2005). There is also evidence that pesticides work synergistically with other stressors to adversely affect fish in the Delta (Clifford et al. 2005).

It is unknown how many farmers in the Delta that would be willing to participate in this conservation measure.

Monitoring and adaptive management considerations: *[**Note to reviewers:** this section is a general summary; more detail will be provided in future iterations.]* For Task 1, the CVRWQCB would be responsible for conducting monitoring necessary to assess the effectiveness of BDCP supported elements of its Irrigated Lands Regulatory Program. The Implementing Entity will provide ongoing review of CVRWQCB monitoring, progress, and other relevant reports related to the effectiveness the Program for reducing contaminant loads in agricultural return flows entering the Delta and providing benefits to covered fish species. The Implementing Entity will coordinate with the CVRWQCB to adjust Program contaminant reduction strategies and funding levels through the BDCP adaptive management process as appropriate based on review of CVRWQCB monitoring and other reports.

For Task 2, the Implementing Entity will monitor the effectiveness of participating farmers/farmer groups in reducing loads of targeted pesticides and herbicides. The types of monitoring that may be appropriate include:

- monitoring changes in targeted pesticide and herbicide loads in agricultural drain water from participant's farmed lands;
- monitoring responses of primary and secondary production to reductions in pesticide and herbicide loads;
- monitoring ambient pesticide levels in effluent and in water samples throughout the Delta; and
- monitoring for incidences of mortality and sublethal effects of pesticides and herbicides on covered fish species throughout the Delta.

The Implementing Entity will also conduct 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 based on monitoring and research results through the BDCP adaptive management process.

Reversibility: This conservation measure is expected to be highly reversible.

OSCM5: Reduce the Loads of Toxic Contaminants in Stormwater Pollution and Urban Runoff by Working with Existing Efforts in the Delta. The BDCP Implementing Entity would coordinate with the Sacramento Stormwater Quality Partnership, the City of Stockton, the City of Tracy, and other smaller municipalities (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 plans/programs would be implemented if benefits are expected to BDCP covered species.

The BDCP Implementing Entity would enter into Memoranda of Agreement (MOAs) or similar binding instruments with stormwater agencies that would describe respective roles and obligations for expenditure of BDCP funding. Elements of the MOA would include a description of specific activities that would be funded by the BDCP, preparation of annual work plans for BDCP funded activities, provisions for documenting work performed, monitoring responsibilities, and provisions for modifying or terminating the MOA.

The BDCP Implementing Entity would be responsible for developing annual work plans in coordination with stormwater agencies and Fishery Agencies that specify the extent of stormwater pollution load reduction activities to be implemented by the cities at funded levels. The stormwater agencies would be responsible for implementing the scope of work and submitting reports as specified in the MOA that demonstrate that the work plan has been successfully implemented.

The BDCP Implementing Entity would be responsible for monitoring the effectiveness of stormwater pollution load reduction activities in achieving covered fish species benefits. This monitoring would be required because of the uncertainties surrounding the population level benefits of reducing stormwater pollution loads on covered fish species (see *Uncertainties/Risks* discussion below). The BDCP Implementing Entity, in coordination with the Fishery Agencies, may discontinue monitoring 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.

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. The BDCP Implementing Entity, in coordination with the Fishery Agencies, would also terminate this conservation measure if the stormwater agencies choose not to enter into a MOA with the BDCP Implementing Entity. 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.

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 toxics 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: Assisting existing efforts to reduce the amount of pollution in stormwater runoff entering Delta waterways is hypothesized to provide benefits to fish species by:

- reducing direct mortality of splittail, delta and longfin smelt, green and white sturgeon, steelhead, and Chinook salmon (all races) from contaminants. Weston et al. (2008) 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);
- 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 2006); and
- 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).

Implementation timeframe: It is anticipated that this conservation measure could be implemented in the BDCP near-term implementation period.

Implementation considerations: The BDCP Implementing Entity would coordinate with each stormwater agency separately because each is under a separate NPDES MS4 permit.

Resiliency to future changes: This conservation measure is not expected to be affected by future changes.

Uncertainties/risks: The effect of some contaminants in stormwater on covered fish species at a population level is not well known.

Monitoring and adaptive management considerations: ***[Note to reviewers:*** *this section is a general summary; more detail will be provided in future iterations.]* Individual cities would be responsible for conducting monitoring necessary to assess the effectiveness of BDCP supported elements of their stormwater management plans. 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 the cities' monitoring and other reports.

Reversibility: Reversibility of this conservation measure is expected to be moderate due to the possibility of needed infrastructure.

[Note OSCM6 was recommended for deletion by the Other Stressors Working Group, as discussed at the 4/3/09 Steering Committee meeting]

Conservation Measure 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 OSCM7 was recommended for deletion by the Other Stressors Working Group. On 4/3/09, the Steering Committee recommended keeping the measure. The following text will be updated based on the Steering Committee discussion.]*** The BDCP Implementing Entity would coordinate with the Port of Stockton, the US Army Corps of Engineers, and the CVRWQCB to identify and implement long-term solutions to dissolved oxygen problems in the Stockton Deep Water Ship Channel at a funding level of $$_____ over the term of the BDCP.

The BDCP Implementing Entity would enter into Memoranda of Agreement (MOAs) or similar binding instruments with the Port of Stockton, the US Army Corps of Engineers, and the CVRWQCB that would describe respective roles and obligations for expenditure of BDCP funding. Elements of the MOA would include a description of specific activities that would be funded by BDCP, preparation of annual work plans for BDCP funded activities, provisions for documenting work performed, monitoring responsibilities, and provisions for modifying or terminating the MOA.

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 by the Port of Stockton the US Army Corps of Engineers, and the CVRWQCB at funded levels. The Port of Stockton, the US Army Corps of Engineers, and the CVRWQCB would be responsible for implementing the scope of work and submitting reports as specified in the MOA that demonstrate that the work plan has

been successfully implemented. The Port of Stockton, the US Army Corps of Engineers, and the CVRWQCB would also be responsible for monitoring the effectiveness of dissolved oxygen improvement measures and, if necessary, adjusting methods to improve their effectiveness over time.

The Port of Stockton, the US Army Corps of Engineers, and the CVRWQCB would be responsible for monitoring the effectiveness of dissolve oxygen enhancement measures in improving dissolved oxygen levels.

The BDCP Implementing Entity, in coordination with the Fishery Agencies, would terminate this conservation measure if the Port of Stockton, the US Army Corps of Engineers, and the CVRWQCB choose not to enter into a MOA with the BDCP Implementing Entity. 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, however, would modify this conservation measure in coordination with the Fishery Agencies as appropriate if an MOA can be entered into with at least one of the agencies of these implementing agencies.

Problem statement: The Stockton Deep Water Ship Channel has been identified as an impaired waterway by the CVRWQCB because of low dissolved oxygen concentrations during late summer and early fall. 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 2007b). The Stockton Deep Water Ship Channel often exceeds the water quality standard established by the Regional Board for dissolved oxygen (CVRWQCB 2007b). The 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. Low dissolved oxygen levels can cause physiological stress and mortality to fish and other aquatic organisms, can impair both upstream and downstream migration of fall-run Chinook salmon, and may affect steelhead and white sturgeon similarly (CRWQCB 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 create a similar barrier to spring-run Chinook salmon.

As a temporary solution, DWR has been experimenting with dissolved oxygen aeration techniques to be used when dissolved oxygen concentrations in the Stockton Deep Water Ship Channel drop below water quality objectives. However, no long-term solution has been identified and funds for this solution have not been identified.

Hypotheses: Identifying and implementing long-term solutions to the dissolved oxygen problem in the Stockton Deep water Ship Channel is hypothesized to:

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

Implementation timeframe: It is anticipated that this conservation measure could be implemented in the BDCP near-term implementation period.

Implementation considerations: This conservation measure may need significant infrastructure for successful implementation.

Resiliency to future changes: The effectiveness of this conservation measure could be affected by future sea level rise and hydrology associated with future climate change, flow changes resulting from Endangered Species Act litigation, and changes in Delta conveyance.

Uncertainties/risks: Although there has been recent research conducted on the causes and mechanisms of dissolved oxygen sags in the Stockton Deep Water Ship Channel (see www.eerp-pacific.org) and CALFED funding for future work, these causes and mechanisms underlying dissolved oxygen sags need to be better studied.

Monitoring and adaptive management considerations: *[**Note to reviewers:** this section is a general summary; more detail will be provided in future iterations.]* The Port of Stockton, the US Army Corps of Engineers, and the CVRWQCB would be responsible for conducting monitoring necessary to assess the effectiveness of BDCP supported elements of this program. The Implementing Entity will provide ongoing review of the Port of Stockton, the US Army Corps of Engineers, and the CVRWQCB monitoring, progress, and other relevant reports related to the effectiveness the Program for improving dissolved oxygen levels in the Stockton Deep Water Ship Channel and providing benefit to covered fish species. The Implementing Entity will coordinate with the Port of Stockton, the US Army Corps of Engineers, and the CVRWQCB to adjust Program dissolved oxygen improvement strategies and funding levels through the BDCP adaptive management process as appropriate based on review of the Port of Stockton, the US Army Corps of Engineers, and the CVRWQCB monitoring and other reports.

Reversibility: Reversibility of this conservation measure is expected to be moderate because major infrastructure may need modification.

[Note: OSCM8 was recommended for deletion by the Other Stressors Working Group, as discussed at the 4/3/09 Steering Committee meeting]

[Note: OSCM 9 was recommended for deletion by the Other Stressors Working Group, as discussed at the 4/3/09 Steering Committee meeting]

OSCM10: Reduce the Risk for Future Introductions of Non-Native Aquatic Organisms from Recreational Watercraft. To implement this conservation measure, the BDCP Implementing Entity would 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 at a funding level of up to $____ over the term of the BDCP. Such a program could establish a certificate 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 would be set up along major driving routes throughout the Delta. The program could be operated under the auspices of DFG game wardens, potentially as part of DBEEP. Funding would 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 would 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 would 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 would enter into a Memorandum of Agreement (MOA) or similar binding instrument with DFG that would describe respective roles and obligations for expenditure of BDCP funding. Elements of the MOA would include a description of specific activities that would be funded by BDCP, requirements for preparation of work plans for BDCP funded activities, provisions for documenting work performed, monitoring responsibilities, and provisions for modifying or terminating the MOA. DFG would also be responsible for monitoring the effectiveness of the inspection program and inspection methods to improve their effectiveness over time.

The BDCP Implementing Entity would review progress or other relevant reports prepared by DFG to assess the effectiveness of the program in reducing risk of the introduction and establishment of non-native species. The BDCP Implementing Entity would coordinate with the DFG to adjust inspection strategies and funding levels through the BDCP adaptive management process as appropriate based on review of agency reports.

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. This conservation measure would also be terminated if DFG chooses not to enter into MOAs with the BDCP Implementing Entity. 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.

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-natives 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 boarders have increased and many reservoirs have begun 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 is in need of development.

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 difficult to hypothesize 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.

Implementation timeframe: It is anticipated that this conservation measure could be implemented in the BDCP near-term implementation period.

Implementation considerations: Significant coordination and funding would be needed for this program to be developed. There would likely be contention among the boating community regarding this conservation measure. Implementation would be accomplished through a funding agreement with DFG or by the transfer of funds.

Resiliency to future changes: This action would not be influenced by future climate change.

Uncertainties/risks: The benefits of this conservation measure cannot be easily predicted but the benefits could be very large depending on the non-native invasive introductions that are prevented and the control or eradication methods that are implemented. Existing non-native invasive species in the Delta have a wide range of substantial impacts on covered species and future introductions would be expected to have a similar range of substantial impacts on covered species. There will always remain the risk that invasive species propagules on recreational vessels will avoid detection to reach and invade the Delta.

Monitoring and adaptive management considerations: *[**Note to reviewers:** this section is a general summary; more detail will be provided in future iterations]* DFG would be responsible for monitoring the effectiveness of BDCP-funded elements of a watercraft inspection program. The BDCP Implementing Entity would review progress or other relevant reports prepared by DFG to assess the effectiveness of the program in reducing risk for the introduction and establishment of non-native species. The BDCP Implementing Entity would coordinate with DFG to adjust inspection strategies and funding levels through the BDCP adaptive management process as appropriate based on review of agency reports.

Reversibility: This conservation measure is expected to be easily reversible.

OSCM11: Provide for Rapid Detection of and Response to New Introductions of Non-Native Species into Delta Waterways. ***[Note: OSCM11 was recommended for deletion by the Other Stressors Working Group. On 4/3/09, the Steering Committee recommended keeping the measure. The following text will be updated based on the Steering Committee discussion.]*** The BDCP Implementing Entity would support the formation of a DFG Delta-specific rapid response team for new non-native introductions into the Delta at a funding level of up to $$_____ over the term of the BDCP. In addition to funding, the BDCP Implementing Entity would assist and work 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 would enter into a Memorandum of Agreement (MOA) or similar binding instrument with DFG that would describe respective roles and obligations for expenditure of BDCP funding. Elements of the MOA would include a description of specific activities and equipment that would be funded by BDCP, preparation of annual work plans for BDCP funded activities, provisions for documenting work performed, monitoring responsibilities, and provisions for modifying or terminating the MOA.

DFG would be responsible for:

- developing annual work plans that specify the extent and types of activities to be implemented by DFG at funded levels for submittal to the BDCP Implementing Entity;
- implementing the scope of work and submitting reports as specified in the MOAs that demonstrate that work plans have been successfully implemented; and
- monitoring the effectiveness of detection and response procedures and improving them as warranted over time.

The BDCP Implementing Entity, in coordination with the Fishery Agencies, would 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. The BDCP Implementing Entity would also terminate this conservation measure if DFG chooses not to enter into a MOA with the BDCP Implementing Entity. 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.

Problem statement: The California Aquatic Invasive Species Program contains 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 could at least partially 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 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.

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 difficult to hypothesize 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). Further, although not yet in the Delta, zebra (*Dreissena polymorpha*) and quagga mussels (*Dreissena rostriformis bugensis*) may soon establish. These mussels have caused >90% mortality of native bivalves in the Mississippi River basin (Ricciardi et al. 1996).

Implementation timeframe: It is anticipated that this conservation measure could be implemented in the BDCP near-term implementation period.

Implementation considerations: Implementation would be accomplished through a funding agreement with DFG and by the transfer of funds.

Resiliency to future changes: This action would be resilient to future climate change because adaptive management is built into the California Aquatic Invasive Species Program.

Uncertainties/risks: The benefits of this conservation measure cannot be easily predicted but the benefits could be very large depending on the success of the control or eradication methods that are implemented. Existing non-native invasive species in the Bay/Delta have a wide range of impacts on covered species and future introductions would be expected to have a similar range of impacts on covered species.

Monitoring and adaptive management considerations: *[**Note to reviewers:** this section is a general summary; more detail will be provided in future iterations]* 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 review of agency reports.

Reversibility: This conservation measure is expected to be highly reversible.

OSCM12: Reduce the Risk for Establishment of Zebra Mussel and Quagga Mussel in Delta Waterways. The BDCP Implementing Entity would support implementation of the following actions to a funding level of $$_____ over the term of the BDCP:

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 would enter into Memoranda of Agreement (MOAs), contracts, or other binding instruments with appropriate entities as needed to implement this conservation measure. Agreements with these entities would describe respective roles and obligations for expenditure of BDCP funding. Elements of agreements would include a description of specific activities and equipment purchases funded by BDCP, preparation of annual work plans for BDCP funded activities, provisions for documenting work performed, monitoring responsibilities, and provisions for modifying or terminating agreements.

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. 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 process.

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 in 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. The introductions of these mussels have caused >90% mortality of native bivalves in the Mississippi River basin (Ricciardi et al. 1996).

Implementation timeframe: It is anticipated that this conservation measure could be implemented in the BDCP near-term implementation period.

Implementation considerations: Implementation would be accomplished through a funding agreement with DFG and DWR and by the transfer of funds.

Resiliency to future changes: This action would be resilient to future climate change because adaptive management is built into both rapid response plans.

Uncertainties/risks: Adverse effects of zebra and quagga mussels on freshwater aquatic ecosystems have been documented across the U.S.

Monitoring and adaptive management considerations: *[**Note to reviewers:** this section is a general summary; more detail will be provided in future iterations]*. 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 would review progress reports or 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.

Reversibility: This conservation measure is expected to be highly reversible.

OSCM13: Remove Non-Native Submerged and Floating Aquatic Vegetation from Delta Waterways. The BDCP Implementing Entity would ensure the removal of Brazilian waterweed (Egeria densa), water hyacinth (Eichhornia crassipes), and other non-native submerged and floating aquatic vegetation (SAV and FAV) from at least __ acres of Delta waterways to increase turbidity conditions and reduce effects of predation on covered fish species (see Rationale discussion below). The BDCP Implementing Entity would ensure the maintenance of areas cleared of SAV and FAV over the term of the BDCP. Unlike the focus of the current program, which determines target treatment locations based on impacts to navigability, BDCP funded actions would target the highest priority migration corridors and habitat for the covered fish species and would be coordinated with and integrated into BDCP habitat restoration and flow operations programs. Following initial removal of SAV and FAV, the reestablishment of SAV and FAV in treated waterways would be monitored to determine the need for subsequent treatments to remove SAV and FAV.

To implement this conservation measure, the BDCP would 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.

The BDCP Implementing Entity would enter into a Memorandum of Agreement (MOA) or similar binding instrument with DBW that would describe respective roles and obligations for expenditure of BDCP funding. Elements of the MOA would include a description of specific activities that would be funded by BDCP, preparation of annual work plans for BDCP funded activities, provisions for documenting work performed, monitoring responsibilities, and provisions for modifying or terminating the MOA. The BDCP Implementing Entity would implement this conservation measure if DBW does not choose to participate in its implementation.

The BDCP Implementing Entity would be responsible for developing annual work plans in coordination with USFWS, NMFS, and DFG (Fishery Agencies) that specify the extent and locations of SAV and FAV control activities to be implemented by DBW at funded levels. Treatment areas would be focused on removing SAV and FAV from channels that support important juvenile salmonid, delta smelt, and longfin smelt habitat use areas. DBW would be responsible for implementing the scope of work and submitting reports as specified in the MOA that demonstrate that the work plan has been successfully implemented. DBW would also be responsible for monitoring the effectiveness of SAV and FAV control measures and adjusting control methods to improve their effectiveness over time.

The BDCP Implementing Entity would be responsible for monitoring the effectiveness of the control activities in achieving covered species benefits. This monitoring would be required because of the uncertainties of the effectiveness of SAV and FAV removal in providing covered fish species benefits such as reduction in predators and increase in turbidity (see *Uncertainties/Risks* below). Monitoring would be conducted to assess the effect of removing SAV and FAV on turbidity levels, predator abundance, and abundance of juvenile salmonids, delta smelt, and longfin smelt in treated channels. The BDCP Implementing Entity in coordination with the Fishery Agencies may discontinue monitoring in future years if monitoring results indicate a strong correlation between SAV and FAV control efforts and responses of covered fish species.

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

If results of monitoring indicate that control of 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.

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..

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) (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

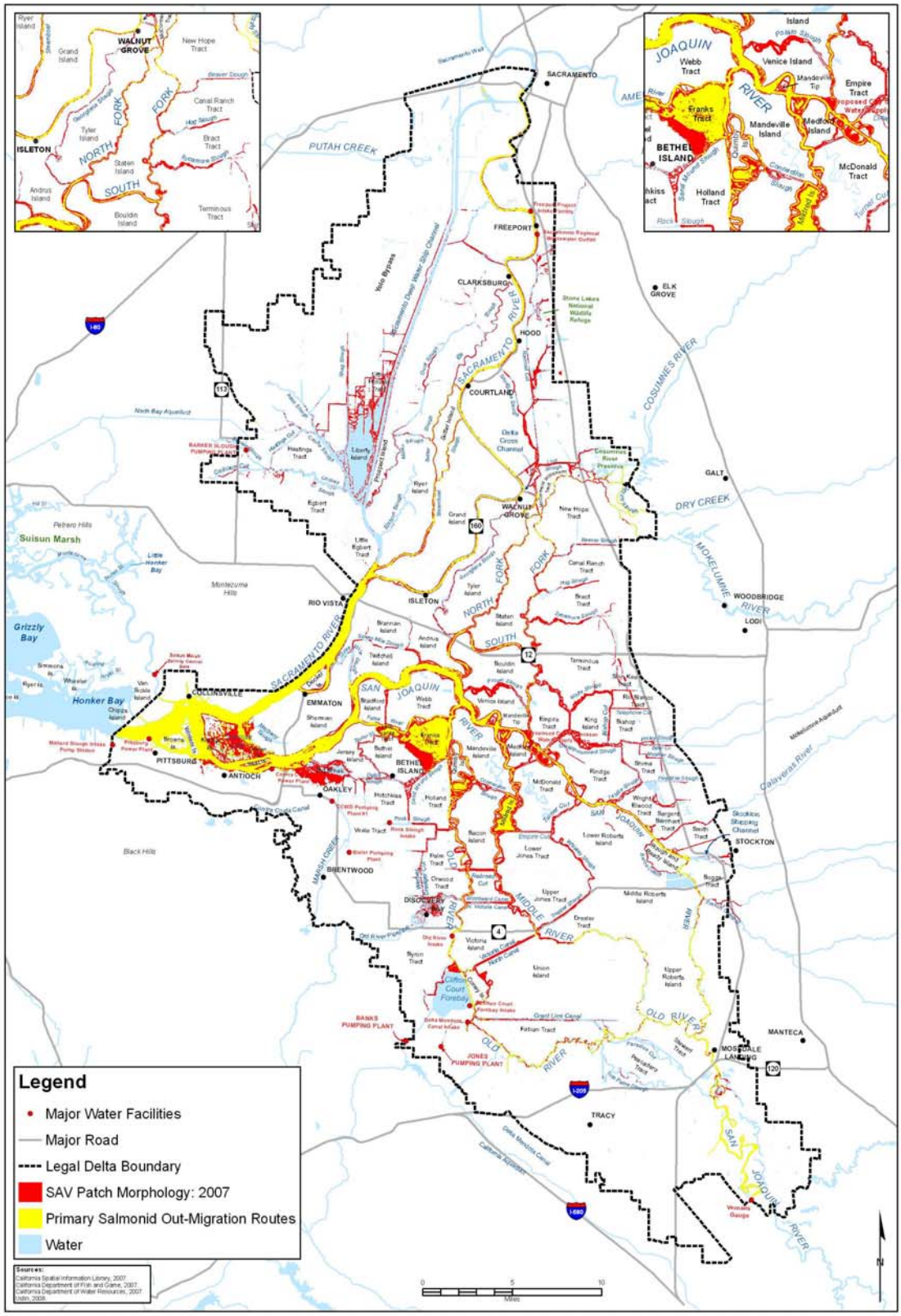

Figure 1. Overlap of SAV in 2007 and Primary Salmonid Outmigration Routes.

(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:

- reduce 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.
- reduce predation mortality of delta smelt due to higher 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).
- increase food consumption by delta and longfin smelt due to higher 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.
- increase rearing habitat for juvenile salmon (all races), steelhead, and splittail. physically obstructing access (IEP 2008a).
- increase 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 SAV/FAV stands.

Implementation timeframe: It is anticipated that this conservation measure could be implemented in the BDCP near-term implementation period.

Implementation considerations: The optimal time for SAV control efforts that rely on Fluridone-based products is early April, which is at the end of the wet season. If the applied herbicide is found to do harm to other ecosystem aspects, its use would be halted. It is difficult to estimate a per-area cost for active channels in the Delta as the current control techniques were developed for relatively enclosed and isolated areas such as Franks Tract where the applied herbicide is not rapidly dispersed by currents.

Resiliency to future changes: One potential changed condition could be a successful invasion of the Delta by either zebra mussel or quagga mussel. Filtering by these mussels could result in rapid reductions in turbidity and potentially allow non-native SAV to grow in much deeper water (due to increased light penetration) leading to much greater extent of SAV and greater impacts on the covered species. If such a changed condition were to occur, the efficacy of this conservation measure would need to be reevaluated.

Uncertainties/risks: There are no well established SAV control methods for channels with substantial currents and new techniques would have to be developed. The continuous use of the same herbicide control method may select for an herbicide-resistance genotype which might render the present control method ineffective. There is a risk that another non-native SAV will invade areas where Egeria is controlled and be resistant to control. Curly leaf pondweed and Eurasian watermilfoil, both non-natives, may become a significant problem in areas where Egeria and water hyacinth have been removed.

Monitoring and adaptive management considerations: The DBW would be responsible for monitoring the effectiveness of BDCP-funded elements of the non-native aquatic vegetation control programs. The BDCP Implementing Entity would review progress reports or 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.

Performance Monitoring Metric #1: Acreage of SAV and FAV treated.

Justification: To ensure that BDCP funding is being used properly for the SAV/FAV removal program, the BDCP Implementing Entity would need verification that additional area is treated in the program as a result of BDCP funding.

Target: Treat __acres of SAV and __acres of FAV annually in Delta waterways.

Adaptive management triggers and responses: If less than __acres are treated each year, action will be taken by the BDCP Implementing Entity to determine the factors limiting progress and to resolve these issues as necessary.

Monitoring approach: Annual reports prepared by DBW would be reviewed by the BDCP Implementing Entity.

Performance Monitoring Metric #2: Change in Biovolume of *Egeria densa* relative to Control Areas

Justification: The most direct way to determine whether treatment of Egeria is effective is to compare the change in biovolume of Egeria before and after treatment/removal to a nearby control location. Egeria biovolume is constantly changing with growth and senescence. Egeria growth is highly variable and dependent on many factors, including nutrient status, light intensity, day length, temperature, turbidity, salinity, and flow rate (Department of Boating and Waterways 2006). As a result, it is necessary to compare changes in Egeria biovolume in treatment locations to nearby control sites with similar levels of these variables. Because biovolume in control plots is expected to change during the period, it is necessary to compare changes and not absolute values of biovolume after treatment. The Department of Boating and Waterways contracted ReMetrix, LLC to perform hydroacoustic analyses on

Egeria to determine biovolume in the Delta, and this method has been deemed "the best evidence to date of site efficacy" by the Department of Boating and Waterways (2006).

Target: There are two performance targets to be met:

1. Reduce the biovolume of Egeria by __% on average after 90 days of treatment in treated areas relative to control areas. A reduction of __% is suggested based on current known efficacy of existing treatments (Department of Boating and Waterways 2008). The 90 day period is currently used by the Department of Boating and Waterways to measure efficacy.
2. No year-over-year increase in pre-treatment biovolume in a treatment site relative to nearby control site.

Adaptive management triggers and responses: There are two adaptive management targets that, if not met, would trigger a re-evaluation and development of more effective removal techniques:

1. If the biovolume of Egeria in cleared areas is not reduced relative to control areas on average after 90 days post-treatment.
2. If there are increases in year-over-year pre-treatment and post-treatment biovolume in a treatment site relative to a nearby control site in more than __% of years over a 10 year period. A period of 10 years is meant to provide sufficient time to account for high interannual variation in determining whether the treatment technique is adequate.

Monitoring approach: Field surveys would be conducted using hydroacoustic analysis, as has been previously conducted, in treatment locations to estimate the biovolume of plants.

If sufficient evidence indicates that treatment/removal is effective by meeting both performance targets above for __ consecutive years, then monitoring can cease. This period accounts for interannual variation and meeting this requirement would be difficult to achieve if the technique were not effective.

Performance Monitoring Metric #3: Change in Areal Coverage of Water Hyacinth relative to Control Areas

Justification: The most direct way to determine whether treatment and/or removal of water hyacinth are effective is to compare the change in areal cover of water hyacinth before and after treatment/removal to a nearby control location. Areal cover of water hyacinth is constantly changing with growth, senescence, and, because it floats, flow patterns. The Department of Boating and Waterways has contracted UC Davis to employ hyperspectral imagery for estimating areal coverage of water hyacinth (Ustin et al 2008).

Target: There are two targets identified:

1. Reduce the areal cover of water hyacinth by __% on average after 90 days of treatment in treatment/removal areas relative to control areas. The 90 day period is currently used by the Department of Boating and Waterways to measure efficacy of Egeria removal and, given that the Department of Boating and Waterways primarily uses chemicals for treatment of both chemicals, this period is expected to be sufficient.
2. No year-over-year increase in pre-treatment areal cover in a treatment site relative to nearby control site.

Adaptive management triggers and responses: If the areal cover of water hyacinth in treatment/removal areas is not reduced relative to control areas on average after 90 days post-treatment, the action would be re-evaluated and different, more effective removal techniques would be developed. Further, if there are increases in year-over-year pre-treatment areal cover in a treatment/removal site relative to a nearby control site for __ consecutive years, the action would be re-evaluated and different, more effective removal techniques would be developed.

Monitoring approach: Field surveys would be conducted using remote sensing areal cover estimates, such as that used by Susan Ustin's lab at UC Davis, in treatment locations to estimate the biovolume of plants.

If sufficient evidence indicates that treatment/removal is effective by meeting both performance targets above for __ consecutive years, monitoring can cease. This period accounts for interannual variation and meeting this requirement would be difficult to achieve if the technique were not effective.

Effectiveness Monitoring Metric #3: Turbidity

Justification: Evidence suggests that Egeria densa reduces turbidity levels by reducing water motion, thereby allowing material to settle out (Grimaldo and Hymanson 1999). Turbidity levels in the Delta have declined over the past 30 years (Wright and Shoellhamer 2004), which may influence the foraging ability and/or predator avoidance of delta and longfin smelt. Delta and longfin smelt are thought to be attracted to high turbidity levels (Feyrer et al. 2007, USBR 2008).

Target: Increase localized turbidity levels by __% from 1 week prior to treatment/removal to 90 days after treatment within the removal area relative to a nearby control location. The period of 90 days will allow sufficient time for the treatment to take effect.

Adaptive management triggers and responses: If, after __ months/years, turbidity does not increase by __% relative to control locations despite a reduction in areal coverage of aquatic vegetation of __%, the action would be re-evaluated and cessation of the conservation measure would be considered if there were no other benefits to removal.

Monitoring approach: The monitoring will coincide with removal of Egeria to allow an experimental monitoring approach. Turbidity levels would be measured using a turbidity meter 1 week prior to and 90 days after removal of Egeria in areas within and nearby treatment/removal locations (BACI approach).

If sufficient evidence indicates that Egeria removal effectively increases localized turbidity levels in removal locations by meeting the performance targets for __ consecutive years, monitoring the effects of removal on turbidity levels can cease. This period accounts for interannual variation and meeting this requirement would be difficult to achieve if the technique were not effective.

Effectiveness Monitoring Metric #4: Local abundance of non-native predatory fish

Justification: The presence of Egeria is hypothesized to provide habitat for non-native predatory fish, particularly largemouth bass (Brown and Michniuk 2007) that may have adverse effects on covered fish species. Thus, the removal of non-native aquatic vegetation should reduce there local abundance of these fish.

Target: Reduced localized abundance of large mouth bass (and other non-native predators, as necessary) by __% from 1 week prior before to 90 days after removal relative to a nearby control location. The value of __% is used because it is considered sufficient to allow survival of covered fish species to increase by __% according to predation studies of large mouth bass

Adaptive management triggers and responses: If, after __ months/years, localized abundance of large mouth bass does not decrease by __% relative to control locations despite a reduction in areal coverage of non-native aquatic vegetation of __%, the action would be re-evaluated and cessation of the conservation measure would be considered.

Monitoring approach: The monitoring will coincide with removal of Egeria to allow an experimental monitoring approach. Abundance would be measured using electrofishing, pop nets, or other unbiased sampling technique for collecting fish in vegetation (in combination with Effectiveness Monitoring Metric #4) 1 week prior to and 90 days after removal of Egeria in areas both within and nearby removal locations (BACI approach).

If sufficient evidence indicates that local abundances of large mouth bass abundance decreases to __ by removing Egeria, monitoring can cease.

Effectiveness Monitoring Metric #5: Local abundance of juvenile salmonids and Sacramento splittail

Justification: The presence of non-native aquatic vegetation is hypothesized to exclude the presence of rearing juvenile salmonids and splittail from shallow tidal marsh and channels (Brown 2003). If true, the treatment/removal of non-native vegetation in these areas would be expected increase the local abundance of these species.

Target: Increase localized abundance of covered fish species by __% from 1 week prior before to 90 days after treatment/removal relative to a nearby control location.

Adaptive management triggers and responses: If, after __ months/years, localized abundance of both juvenile splittail and Chinook salmon species does not increase after removal of Egeria in at least __% of the sites relative to control locations, the action would be re-evaluated and cessation of the conservation measure would be considered.

Monitoring approach: Monitoring will coincide with removal of Egeria to allow an experimental monitoring approach. Abundance would be measured using electrofishing, pop nets, or other unbiased sampling technique for collecting fish in vegetation (in combination with Metric #5) 1 week prior to and 90 days after treatment/removal of non-native aquatic vegetation in areas both within and nearby treatment/removal locations (BACI approach).

If sufficient evidence indicates that local abundances of juvenile salmonids and splittail increase after Egeria removal by at least as much as the performance criteria for 5 consecutive years, monitoring can cease.

Reversibility: The implementation of the program could be terminated immediately without impacts on covered species. Areas where SAV/FAV is controlled may be subject to reinvasion by the same species of SAV/FAV or potentially by species with greater ecological impacts that invade the Delta in the future or which are currently present in low numbers.

OSCM14: Increase the Harvest of Non-Native Predatory Fish to Decrease their Abundance. The BDCP Implementing Entity would develop, in coordination with the Fishery Agencies, a proposal describing recommended fishing regulations that relax the size and daily bag limits for non-native invasive predatory fish species in the Delta (e.g., centrarchids and striped bass) for submittal to the California Fish and Game Commission for their consideration and adoption. The purpose of relaxing harvest recommendations would be to reduce the abundance and average size of predatory fish sufficiently to improve survivorship of covered fish species. The proposal would include a description of monitoring that would be conducted to assess the effectiveness of the regulations in reducing the abundance and size of non-native predatory fish and reducing predation on covered fish species. Based on monitoring results, if predator abundance and predation levels on covered fish species are not measurably reduced, the BDCP Implementing Entity in coordination with the Fishery Agencies may prepare subsequent proposals requesting that the regulations on size and bag limits be further relaxed or requesting that the original regulations be reinstated. In addition, the proposal would describe the processes, monitoring requirements, and findings that would be required from the regulation. The BDCP Implementing Entity would conduct ongoing consultation and coordination with the Fish and Game Commission to facilitate consideration of the proposal.

Problem statement: Despite the decline of multiple native species in the Delta over the past few years, such as delta smelt (IEP 2008a), longfin smelt (IEP 2008a), and salmon (MacFarlane et al. 2008), the abundance of non-native centrarchids such as large mouth bass have increased, possibly associated with increases in Egeria abundance (Brown 2003, Grimaldo et al. 2004). Predation by non-native centrarchids in the Delta is thought to reduce the survival rates of juvenile salmonids and splittail, although the effect of centrarchids on smelt and sturgeon in the Delta may be minor due to their use of different locations in the water column (M. Nobriga pers. comm.). Striped bass in the Delta are thought to consume juvenile salmonids primarily and may possibly consume delta and longfin smelt and splittail (M. Nobriga pers. comm.). The impact of non-native basses on juvenile sturgeon is likely small in the Delta.

Hypotheses: Relaxation of size and daily bag limits for striped bass and centrarchids is hypothesized to:

- reduce populations of adult and sub-adult striped bass and centrarchids. Humans have been extremely effective historically at harvesting fish species to very low numbers in many parts of the world;
- subsequently reduce the population of fry and juvenile striped bass and centrarchids. Relaxing size limits is expected to allow smaller fish to be harvested, potentially before they have reached a reproductive size, thereby reducing the reproductive capacity of the population;
- reduce predation mortality of Chinook salmon (ODFW 1998, Lindley & Mohr 2003, Nobriga et al. 2003, Nobriga & Feyrer 2007,2008), steelhead (ODFW 1998), delta smelt (Stevens 1966, Winemiller & Rose 1992, Moyle 2002, Eisermann 2006, Nobriga and Feyrer 2007, 2008), longfin smelt (Nowak et al. 2004, Eisermann 2006), Sacramento splittail (Moyle et al. 2004, Eisermann 2006, Nobriga & Feyrer 2007, 2008), green sturgeon (J. Israel, pers. obs.), and white sturgeon by striped bass and centrarchids; and
- reduce competition for food with delta and longfin smelt by juvenile striped bass (Orsi & Mecum 1996, Kimmerer 2002b, M. Nobriga, pers. comm.).

Implementation timeframe: It is anticipated that this conservation measure could be implemented in the BDCP near-term implementation period.

Implementation considerations: The conservation measure contributes to the reduction of the recreational fishery for these species. As a result, there will likely be opposition to this conservation measure by the angling community. The effectiveness of this conservation measure may be limited by anglers continuing catch and release practices and trying to preserve the fishery in the Delta.

By allowing anglers to take more individuals of these species, anglers may consume more fish than what is recommended by the Office of Health Hazard Assessment to minimize the human health risk of exposure to mercury that has accumulated in the fish tissue. This may be offset in part, because the fish taken would be younger and smaller and thus may not have accumulated as much mercury.

Resiliency to future changes: This conservation measure is not expected to be affected by future change.

Uncertainties and risks: If harvest of non-native fishes does not substantially increase, this measure may not have a population effect on those non-natives and hence may not result in benefits to covered species through reduced predation. There is low certainty in the magnitude of overall effects of this conservation measure on covered fish species because the relationship between non-native predator species and covered fish species is not well understood and many factors other than non-native predation affect the mortality of covered species.
Potential risks associated with this measure include:

- Increased bycatch of non-target species during fishing efforts targeted at striped and black bass.
- Release other predator populations from predation pressure currently imposed by striped and black bass (Swingle 1946, Shroyer et al. 2003, Missouri Department of Conservation 2006, Nobriga & Feyrer 2008).
- Release other competitor populations from predation pressure currently imposed by striped and black bass (Begon et al. 1996, Gleason & Bengston 1996, Dettmers et al. 1998, Bennett 2005, Nobriga and Feyrer 2008).
- Unintended changes to the striped and black bass populations (e.g., decreased abundance but increased average size) (Mayo et al. 1998, Hartman 2003).

Monitoring and adaptive management considerations: *[**Note to reviewers:** this section is a general summary; more detail will be provided in future iterations.]* Monitoring would consist of assessing the abundance, distribution, and size of centrarchid species before and after implementation of new regulations to determine the effectiveness of regulations. Studies would be conducted to determine size-based predation rates of centrarchids on covered fish species to determine whether relaxation of the regulations has an impact on these species.

If results of fish monitoring indicate that relaxation of regulations have not been sufficient to significantly reduce adverse affects of non-natives on native fish, actions would be modified to be more effective through the adaptive management process.

Reversibility: This conservation measure is expected to be highly reversible.

[Note: OSCM15 was removed from consideration by the Other Stressors Sub-Group]

OSCM16: Reduce Illegal Harvest of Chinook Salmon, Central Valley Steelhead, Green Sturgeon, and White Sturgeon in the Delta. To reduce the adverse effects of illegal harvest of adult covered salmonids and sturgeon, the BDCP would increase the enforcement of fishing regulations for these species in the Delta. The BDCP Implementing Entity would 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. BDCP-supported DBEEP staff would be tasked specifically with enforcing laws and regulations regarding harvest of the covered fish species. Estimated funding would 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 BDCP Implementing Entity would enter into a Memorandum of Agreement (MOA) or similar binding instrument with DFG that would describe respective roles and obligations for expenditure of BDCP funding. Specifically, the MOA would include a description of specific law enforcement and supporting positions and the types and levels of field law enforcement activities that would be funded by BDCP; preparation of annual work plans for BDCP funded activities; provisions for documenting work performed; and provisions for modifying or terminating the MOA.

DFG would be required to monitor and annually report the activities and results of DBEEP activities funded by BDCP, including an account of the specific benefits to covered fish species as a result of enforcement actions.

The BDCP Implementing Entity would review progress reports and other relevant reports prepared by the DBEEP to assess the Program's ongoing effectiveness in decreasing the adverse effects of illegal harvest on covered fish species. 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.

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.

> **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).
>
> **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 CDFG pers. comm., Z. Matica DWR 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).

The magnitude of benefit of this measure is 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).

Implementation timeframe: It is anticipated that this conservation measure could be implemented in the BDCP near-term implementation period.

Implementation considerations: This conservation measure is considered to be readily implementable because it would involve the expansion of an existing program.

Resiliency to future changes: This action would not be influenced by future climate change.

Uncertainties and risks: The effects of illegal harvest on covered fish species, other than white sturgeon, are relatively unknown. Consequently, the benefits of enhanced enforcement for species other than white sturgeon may be limited. The primary risk associated with this measure is that the information gap about where poaching is most important may result in effort being directed at less important areas and may shift poaching to areas with greater importance to the population (Gentner 2004, Moeltner 2006).

Monitoring and adaptive management: The BDCP Implementing Entity would review progress reports and other relevant reports prepared by the DBEEP to assess the Program's ongoing effectiveness in decreasing the adverse effects of illegal harvest on covered fish species. 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.

Performance Monitoring Metric #1: Hiring of additional DBEEP staff

Justification: Hiring of additional DBEEP wardens will be necessary to achieve enhanced enforcement of fishery regulations for covered species.

Target: Hire _ wardens within __ years of BDCP implementation.

Adaptive management triggers and responses: If additional DBEEP wardens are not hired according to targets, action will be taken by the BDCP Implementing Entity to determine the factors limiting progress and to resolve these issues as necessary

Monitoring approach: The BDCP Implementing Entity will review annual reports provided by DBEEP to determine the success in filling the positions described and how positions were attempted to be filled.

Effectiveness Metric #1: Average number of citations issued per contact

Justification: It is predicted that the average number of citations per contact could remain constant as more wardens are added or could at some level of staffing begin to decline, indicating that the increased number of wardens had reduced the amount of illegal fishing in the Delta.

Performance target: While keeping a consistent or higher number of contacts per warden, the average number of citations per warden contact in a given year will decline once the

number of wardens patrolling the Delta is sufficient to reduce the rate of illegal harvest of Chinook salmon, Central Valley steelhead, green sturgeon, and white sturgeon in the Delta.

Adaptive management trigger: The BDCP Implementing Entity would consider the number of wardens staffed in DBEEP as a sufficient number to reduce illegal harvest at such time as a __-year average decline in citation rate per contact begins for all target species (Chinook salmon, Central Valley steelhead, green sturgeon, and white sturgeon), given that the number of contacts per warden is the same or higher than previous years. At this time, the BDCP Implementing Entity would determine whether the number of wardens is optimal. At some point in the future, if the number of citations per contact begins to increase, the BDCP Implementing Entity could reconsider funding more wardens up to 17. If the number of citations becomes very low the BDCP Implementing Entity could consider terminating funding for some positions.

Monitoring approach: The total number of contacts with the public and the total number of citations issued per year would be monitored annually and compared among 3-year increments.

Reversibility: This conservation measure is considered to be easily reversible.

OSCM17: Reduce Adverse Effects of Harvest on Sacramento Splittail Abundance. The BDCP Implementing Entity would develop, in coordination with the Fishery Agencies, a proposal describing recommended Sacramento splittail harvest regulations for submittal to the California Fish and Game Commission for their consideration and approval. The proposal would recommend regulations establishing bag and size limits for Sacramento splittail throughout its native range to maintain and enhance splittail populations. In addition, the proposal would describe the processes, monitoring requirements, and funding that would be required to implement the regulation. The BDCP Implementing Entity will conduct ongoing consultation and coordination with the Fish and Game Commission to facilitate consideration of the proposal.

Problem statement: There are currently no regulations on the Sacramento splittail fishery. However, the fishery may be considerable despite its poor documentation (Moyle et al. 2004).

Hypotheses: This conservation measure would establish legal limits for splittail based on known abundance and harvest rates. Although harvest is not thought to have significant effects on the population currently, this measure is expected to protect the species if harvest pressure were to increase in the future.

Specifically, this conservation measure is hypothesized to:

- increase the population abundance of Sacramento splittail (Moyle et al. 2004, DFG Creel Data 2007-08, USBR 2008). By reducing the number of fish being harvested, more fish can survive to reproduce.
- improve the transfer of energy through the foodweb in wetter years. Splittail are highly fecund in wetter years (Sommer et al. 1997, Feyrer et al. 2007b). It is thought that a large number of larval and juvenile splittail during these years are consumed by other organisms, thus contributing to an increase in the transfer of energy through the foodweb.
- increase predation on Corbula. Because splittail have been shown to consume Corbula (Feyrer et al. 2003), it is hypothesized that an increase in the splittail population would lead to an increased consumption of Corbula.

Implementation timeframe: It is anticipated that this conservation measure could be implemented in the BDCP near-term implementation period.

Implementation considerations: This conservation measure is considered to be moderately practicable and feasible. There may be contention by the angling community over new regulations. Further, educating the public about new regulations and creel surveys may require additional resources from DFG.

Resiliency to future changes: This action would not be influenced by future climate change.

Uncertainties and risks: Because documentation of this fishery is poor, it is difficult to assess the potential effectiveness of this conservation measure in the near term. There is low certainty that harvest has a population level effect on splittail. The primary risk associated with this measure is the potential for redirection of fishing effort to other sensitive species (Gentner 2004), but the likelihood of this risk is relatively unknown.

Monitoring and adaptive management considerations*: [Note to reviewers: this section is a general summary; more detail will be provided in future iterations.]* DFG would be responsible for monitoring the effectiveness of regulations in conserving Sacramento splittail while providing for a recreational fishery, and for revising regulations as needed to improve their effectiveness. The BDCP Implementing Entity would coordinate with DFG to develop and fund monitoring efforts, and to identify and support needed adjustments in regulations in future years.

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. To minimize potential adverse effects of stocking hatchery reared salmonids on wild salmonid stocks, the BDCP Implementing Entity would support the accelerated development and implementation of Hatchery and Genetic Management Plans (HGMPs) for all six 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 would enter into Memoranda of Agreement (MOAs) or similar binding instruments with hatchery operators of Fishery Agencies that would describe respective roles and obligations for expenditure of BDCP funding. Elements of the MOAs would include a description of specific activities that would be funded by BDCP, requirement for preparation of annual work plans for BDCP funded activities, provisions for documenting work performed, monitoring responsibilities, and provisions for modifying or terminating the MOAs.

The BDCP Implementing Entity, in coordination with the Fishery Agencies, would be responsible for developing annual work plans that specify the extent and types of activities to be implemented by the Fishery Agencies at funded levels. The Fishery Agencies would be responsible for implementing the scope of work and submitting reports as specified in the MOAs that demonstrate that work plans have been successfully implemented. The Fishery Agencies would also be responsible for monitoring the effectiveness of HGMP measures and adjusting hatchery management practices to improve their effectiveness over time.

The Fishery Agencies would be responsible for monitoring the effectiveness of HGMPs in improving the genetic integrity of wild salmonid stocks over time. The BDCP Implementing Entity would use results of effectiveness monitoring to determine if implementation of HGMPs results in measurable benefits to covered salmonids 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 results of monitoring indicate that implementation of HGMPs do not substantially and cost-effectively benefit covered salmonids, the BDCP Implementing Entity, in coordination with Fishery Agencies, may terminate this conservation measure. This conservation measure would also be terminated if the Fishery Agencies choose not to enter into MOAs with the BDCP Implementing Entity. If terminated, remaining funding would be deobligated from this conservation measure and reallocated to augment funding for other conservation measures identified in coordination with the Fishery Agencies through the BDCP adaptive management process that more effectively provide covered salmonid benefits.

Problem statement: There is concern that hatchery-reared Chinook salmon have negative effects on wild Chinook salmon, 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 larger hatchery fish outcompete their smaller wild-reared conspecifics for food and space (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).

Due to these problems, hatcheries have begun to reform 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 of wild salmon (ISAB 2003, Goodman 2005, Hey et al. 2005);
- reduce competition for rearing and spawning habitat and food with hatchery reared salmon (Flagg et al. 2000, Goodman 2005); and

Implementation timeframe: It is anticipated that this conservation measure could be implemented in the BDCP near-term implementation period.

Implementation considerations: This conservation measure is considered to be practicable and feasible because efforts to develop HGMPs are already underway.

Resiliency to future changes: This action would not be influenced by future climate change, although hatcheries may need to contend with predicted changes in water temperature.

Uncertainties/risks: It is difficult to determine the benefits of HGMPs. Because HGMPs are not yet completed for Central Valley hatcheries, the actions that will be recommended are unknown at this time. However, some specific actions that could yield measurable benefits can be

implemented before completion. The BDCP Implementing Entity would determine which additional actions to support once implementation of HGMPs are completed based on their ability to benefit the BDCP covered species.

Monitoring and adaptive management considerations: *[**Note to reviewers:** this section is a general summary; more detail will be provided in future iterations.]* The National Marine Fisheries Service would be responsible for monitoring the effectiveness of HGMPs for conserving wild Central Valley salmonid stocks. The BDCP Implementing Entity will provide ongoing review of National Marine Fisheries Service monitoring, progress, and other relevant reports to assess the effectiveness of Central Valleys HGMPs for improving wild salmonid stocks. The Implementing Entity will coordinate with the National Marine Fisheries Service to adjust HGMP strategies and funding levels through the BDCP adaptive management process as appropriate based on review of NMFS reports.

Reversibility: This conservation measure is considered highly reversible.

OSCM19: Reduce Losses of Wild Stocks of Chinook Salmon to Commercial Fishing and Recreational Fishing through a Mark-Select Fishery. To reduce unintentional harvest of wild stocks of Chinook salmon, the BDCP Implementing Entity will support total marking of hatchery produced fall-run Chinook salmon to provide the basis for implementing a mark-select fishery and to contribute to conservation and recovery of the species at a funding level of $$_____ over the term of the BDCP. The ultimate goal of this measure would be to reduce the adverse effects of the mixed stock fishery on covered salmon stocks by allowing visual distinction between hatchery and wild fish by fishermen. Because they would be distinguishable, marked (hatchery) fish could be harvested whereas unmarked (wild) fish would be released when caught.

There are two components to this conservation measure: (1) support 100% marking of salmon reared in fall-run Chinook salmon production hatcheries in California's Central Valley[1], and (2) encourage the California Fish and Game Commission and the Pacific Fish Marine Counsel to implement a mark-selective fishery. The latter would be accomplished by campaigning to these agencies by the BDCP Implementing Entity at a funding level of $$___ over the term of the BDCP or until a mark-select fishery is established.

The BDCP Implementing Entity would enter into Memoranda of Agreement (MOAs) or similar binding instruments with hatchery operators of Fishery Agencies that would describe respective roles and obligations for expenditure of BDCP funding. Elements of the MOAs would include a description of specific activities and equipment purchases that would be funded by BDCP, preparation of annual work plans for BDCP funded activities, provisions for documenting work performed, monitoring responsibilities, and provisions for modifying or terminating the MOAs.

The Fishery Agencies would be responsible for:

- developing annual work plans that specify the extent and types of activities to be implemented by the Fishery Agencies at funded levels for submittal to the BDCP Implementing Entity;
- implementing the scopes of work and submitting reports as specified in the MOAs that demonstrate that work plans have been successfully implemented;

[1] All hatchery reared winter-, spring-, and late fall-run Chinook salmon in Central Valley production hatcheries are currently marked with an adipose fin clip.

- monitoring the effectiveness of marking techniques and improving those techniques if warranted over time; and
- monitoring the effectiveness of the mark-select program for reducing levels of unintended harvest of wild Chinook salmon.

The BDCP Implementing Entity would use results of effectiveness monitoring to determine if implementation of the marking program and the mark-select fishery results in measurable benefits to wild Chinook salmon stocks 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 results of monitoring indicate that the mark-select fishery program does not substantially and cost-effectively benefit covered wild Chinook salmon stocks, the BDCP Implementing Entity, in coordination with Fishery Agencies, may terminate this conservation measure. This conservation measure would also be terminated if the Fishery Agencies choose not to enter into MOAs with the BDCP Implementing Entity. If terminated, remaining funding would be deobligated from this conservation measure and reallocated to augment funding for other conservation measures identified in coordination with the Fishery Agencies through the BDCP adaptive management process that more effectively provide Chinook salmon benefits.

Problem statement: Most hatcheries in the Central Valley are production hatcheries designed to mitigate for lost habitat from dams constructed in the middle of the twentieth century (Williams 2006). However, hatchery-produced Chinook salmon and steelhead are thought to have negative effects on wild fish via competition for resources and genetic effects that can reduce the fitness of wild fish if interbreeding occurs (see ISAB 2002 for review).

Hypotheses: Although the greatest benefits of this conservation measure would be realized if a mark-selective fishery were implemented, it is expected that there would be major benefits to wild stocks of Chinook salmon of mass marking hatchery fish. Specifically, marking 100% of hatchery reared fish is hypothesized to:

- increase the knowledge base regarding Central Valley Chinook salmon (population sizes, harvest rates, success of restoration and river management programs, and other key biological parameters) for improved management (it is unknown whether current management programs primarily benefit wild fish, hatchery fish, or both, and in what proportion) (Hankin 1982, JHRC 2001, ISAB 2003, PSC-SFEC 2005, 2008a, AFS Position Paper 2009, Mohr 2009,);
- increase the ability for hatcheries to track and manage the composition of wild versus hatchery origin fish in breeding programs, detect and quantify straying rates of hatchery fish, and improve broodstock management (with tagging, much improved) (ISAB 2003, AFS Position Paper 2009); and
- streamline, simplify, and reduce costs for coded wire tag, scale, otolith, and genetics sampling programs that specifically target wild or hatchery fish. Targeted fish would be easily identifiable with a visual mark leading to more efficient collection of targeted fish and reduced "bycatch" of non-targeted fish.

If the Fish and Game Commission and Pacific Fish Marine Counsel implement a mark-selective fishery, it is hypothesized that benefits would include:

- Reduce harvest-related mortality of wild Chinook salmon, thus contributing to the recovery of all covered Chinook salmon races (Cramer et al. in press); and
- reduce competition and genetic introgression from hatchery fish with natural fish on spawning grounds due to increased harvest of hatchery fish and the ability for managers to visually segregate hatchery reared fish from wild fish (Hankin 1982, Flagg et al. 2000, Goodman 2005, Weber & Fausch 2005, Araki et al. 2006, AFS Position Paper 2009, Mohr 2009);

DFG has marked and tagged a constant fraction (25%) of hatchery reared fall-run fish since 2007, which been proposed to be sufficient to gain information about life history parameters (Newman et al. 2004). However, additional benefits associated with harvest reductions of wild fish and increased harvest of hatchery fish are predicted to be greatly increased with 100% marking of hatchery fish compared to 25% (Cramer et al in press.).

Implementation timeframe: It is anticipated that this conservation measure could be implemented in the BDCP near-term implementation period.

Implementation considerations: This conservation measure is expected to be moderately practicable and feasible. Marking techniques are currently being implemented and funding would allow for 100% marking. To gain benefits to covered fish species in the way that the conservation measure intends, agencies must agree to implement this action at their hatcheries and to implement the mark-select fishery.

Resiliency to future changes: This action is not expected to be influenced by future climate change.

Uncertainties and risks: Although modeling efforts and similar programs in the Pacific Northwest indicate that a mark select fishery provides benefits to wild fish (e.g., Cramer et al. in press), there is still some uncertainty as to whether this would be beneficial to Central Valley hatcheries. Some of this uncertainty arises from a lack of information regarding non-catch mortality, and approaches for management of conservation stocks that do not utilize surrogate production fish as an indicator for conservation fish.

Potential risks associated with this measure include:

- complication of management and data for conservation hatcheries (e.g., Livingston-Stone), harvest management, and monitoring programs (PSC-SFEC 2003, 2005, 2008a, 2008b, Alexandersdottir 2007); and
- increased harvest of hatchery fish, which may result in higher bycatch of covered salmonids (Hankin 1982, Wertheimer 1988, Bendock & Alexandersdottir 1993, Grover 1995a, Lawson & Sampson 1996, Cox-Rogers et al. 1999, Boydstun 2001 Grover et al. 2002,, Lindsay et al. 2004, Askey et al. 2006, PFMC 2008a, 2008b, Kostow 2008, Cramer in press).

Monitoring and adaptive management: *[**Note to reviewers:** this section is a general summary; more detail will be provided in future iterations.]* The Fishery Agencies would be responsible for monitoring the effectiveness of a mark-select fall-run Chinook salmon fishery program for conserving wild fall-run stocks. The BDCP Implementing Entity would provide funding and ongoing review of Fishery Agencies' monitoring, progress, and other relevant reports to assess the effectiveness of the mark-select fishery for improving wild stocks of fall-run Chinook salmon. The BDCP Implementing Entity would coordinate with the Fishery Agencies to adjust mark-

select strategies and funding levels through the BDCP adaptive management process as appropriate based on review of the Fishery Agencies' reports.

Reversibility: This action is considered moderately reversible. A moderate amount of equipment would be needed to implement the program.

OSCM20: Establish New and Expand Existing Conservation Propagation Programs for Delta and Longfin Smelt. The BDCP Implementing Entity would support: (1) the development of a delta and longfin smelt conservation hatchery by the USFWS to permanently house a delta smelt refuge population and provide a source of delta and longfin smelt for supplementation or reintroduction, as necessary, 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 in case of a catastrophic event in the wild, at a funding level of $$_____ over the term of the BDCP.

The new facility proposed by the USFWS would house genetically-managed refuge populations of delta and longfin smelt (Clarke 2008). Further, the facility would provide fish stocks to supplement the wild population and provide fish stocks for reintroduction, as necessary and appropriate. The facility is expected to be designed for 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. If and when populations of these species are considered recovered, specific rules would be established to close the conservation hatchery.

In addition, the UC Davis Fish Conservation and Culture Laboratory is in need of additional space to expand the refugial population of delta smelt and establish a refugial population of longfin smelt.

The BDCP Implementing Entity would enter into Memoranda of Agreement (MOAs) or similar binding instruments with the USFWS and University of California, Davis that would describe respective roles and obligations for expenditure of BDCP funding. Elements of the MOAs would include a description of specific activities and capital improvements that would be funded by the BDCP, preparation of annual work plans for BDCP funded activities, provisions for documenting work performed, monitoring responsibilities, Hatchery and Genetic Management Plan (HGMP) development and implementation, and provisions for modifying or terminating the MOAs.

USFWS and University of California, Davis would provide the BDCP Implementing Entity with annual work plans that describe activities or capitol improvements that would be funded by BDCP. USFWS and University of California, Davis would be responsible for implementing the scope of work and submitting reports as specified in the MOAs that demonstrate that work plans have been successfully implemented. USFWS and University of California, Davis would be responsible for demonstrating the effectiveness of the conservation hatchery operations and refugial population efforts, respectively, in maintaining and/or improving the genetic integrity of delta smelt and longfin smelt and in propagating sufficient stocks for stocking purposes, if needed, to supplement or recover the wild population. State-of-the-art genetic management practices would be implemented to avoid hatchery produced fish becoming genetically different from wild fish.

The BDCP Implementing Entity in coordination with the Fishery Agencies would use progress reports 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 the program assessments indicate that operation of the conservation hatcheries is not effective in achieving delta smelt and longfin smelt conservation objectives, the BDCP Implementing Entity in coordination with Fishery Agencies may terminate this conservation measure. This conservation measure would also be terminated if the USFWS and University of California, Davis decide not to enter into MOAs with the BDCP Implementing Entity. If terminated, remaining funding would be deobligated from this conservation measure and reallocated to augment funding for other conservation measures identified in coordination with the Fishery Agencies through the BDCP adaptive management process that more effectively provide benefits for delta smelt and longfin smelt.

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.

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

- 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,
- preserve genetic diversity of delta and longfin smelt (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), and
- 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.

Implementation timeframe: It is anticipated that this conservation measure could be implemented in the BDCP near-term implementation period.

Implementation considerations: Delta smelt have been reared in smaller-scale facilities, but a full-scale refugial population has never been supported in a hatchery facility. The ability to maintain genetic diversity and integrity in a smelt hatchery necessary for wild survival is unknown. An important consideration would be development of appropriate criteria for determining under what conditions support of smelt hatchery production and maintenance of refuge populations is no longer necessary. Although there are criticisms of the effectiveness of artificial propagation in maintaining proper genetic diversity and integrity, there may be a point at which there is no alternative.

Resiliency to future changes: Because delta smelt are thought to be near their temperature threshold, additional warming may require an increase reliance on refuge populations.

Uncertainties and risks: Causes of declines in delta and longfin smelt abundance are not well understood. As a result, although this conservation measure would produce more fish, it may not be effective in producing functional fish that are able to survive and reproduce in the wild. The ability to maintain genetic diversity and integrity in a smelt hatchery necessary for wild survival is unknown, and information regarding appropriate techniques for longfin smelt hatchery propagation is limited. The number of fish needed to boost spawning in the wild is also unknown, and the ecological and genetic effects of adding hatchery fish to the wild population are unknown.

Potential risks associated with this conservation measure are as follows:

- Negative genetic consequences for hatchery and wild populations of delta and longfin smelt (B. Clarke, pers. comm., Komen et al. 2006, Kostow 2008, Fraser 2008, Alo & Turner 2005).
- Negative ecological interactions with wild fish (e.g., competition, displacement) (B. Clarke, pers. comm., Kostow 2008, Nobriga & Feyrer 2007, 2008, Nobriga et al. 2008, Bennett et al. 2008, Miller 2005).
- Mining of wild populations for broodstock needs (but see Swanson et al. 1996).
- Mortality associated with catching broodstock (genetic material lost) (but see Swanson et al. 1996, B. Clarke, pers. comm.).

Monitoring and adaptive management: The U.S. Fish and Wildlife Service would be responsible for monitoring the effectiveness of BDCP supported delta smelt and longfin smelt hatchery and refuge population programs. The BDCP Implementing Entity would provide funding and ongoing review of U.S. Fish and Wildlife Service progress and other relevant reports to assess the effectiveness of rearing smelt in hatcheries and maintaining refuge populations. The BDCP Implementing Entity would coordinate with the U.S. Fish and Wildlife Service to adjust hatchery and refuge population management strategies and funding levels through the BDCP adaptive management process as appropriate based on review of U.S. Fish and Wildlife Service reports.

Performance Metric #1: Ability to hold fish successfully in the hatchery

Justification: Establishment of refugial populations of delta and longfin smelt depends upon the ability to house these fish in the hatchery successfully (i.e., with limited mortality).

Target: Limit mortality of delta and longfin smelt to XX% of those collected for broodstock, and to XX% of those produced in the hatchery.

Monitoring approach: Determine mortality rates of fish collected for broodstock and of fish produced at the hatchery for each collection and spawning.

Adaptive management trigger and response: If mortality rates of hatchery fish and those collected for broodstock exceed the targets listed above, the USFWS or UCD will develop strategies to improve survival.

Effectiveness Monitoring Metrics #1: Maintenance of genetic diversity in hatchery fish

Justification: Genetic diversity in hatcheries is often lower than that in wild populations. Loss of genetic diversity may compromise the ability of fish produced in the hatchery to adapt to varying conditions in the wild and may also reduce the genetic diversity of the wild population if these hatchery produced fish are released into the wild.

Target: Maintain the effective population size of delta and longfin smelt hatchery populations at ___ fish.

Monitoring approach: Using standard genetic diversity laboratory techniques, compare the genetic diversity of subsequent generations of hatchery fish to that of fish collected initially for the broodstock. Also, if fish are released into the wild, measure the genetic diversity of wild delta and longfin smelt collected before and periodically after supplementation is initiated.

Adaptive management triggers and responses: If target genetic diversity is not maintained over multiple generations, revise the genetic management plan as necessary.

Effectiveness Monitoring Metric #2: Hatchery fish production success for refugial population

Justification: Establishment of refugial populations of delta and longfin smelt depends upon the ability to produce sufficient numbers of hatchery fish to maintain hatchery stocks indefinitely.

Target: Production of ___ delta smelt and ___ longfin smelt to allow for production of multiple generations, and maintain genetic diversity of refugial populations, as in Effectiveness Monitoring Metric #1 above.

Monitoring approach: Evaluate frequency of successful spawning events and number of fish produced relative to that needed to maintain hatchery populations with appropriate genetic diversity.

Adaptive management trigger and response: If the numbers of fish produced in the hatchery are not sufficient to support production of multiple generations, hatchery practices or capacity will be modified to decrease mortality or increase production.

Effectiveness Monitoring Metric #3: Hatchery fish production for supplementation

Justification: Supplementation of wild populations of delta and longfin smelt will depend upon production of sufficient numbers of hatchery fish to maintain hatchery stocks while introducing a portion of these fish to the wild.

Target: Production ___ delta smelt and ___ longfin smelt from the conservation hatchery to allow for supplementation as well as maintenance of hatchery stocks. Genetic diversity must be maintained as described in Effectiveness Monitoring Metric #1 above.

Monitoring approach: Evaluate the number of fish successfully produced by the hatchery relative to need for outplanting. Identify and monitor factors limiting production.

Adaptive management triggers and responses: If the numbers of fish produced in the hatchery are not sufficient to support supplementation, hatchery practices or capacity will be modified to decrease mortality or increase production.

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. To implement this conservation measure, the BDCP Implementing Entity would 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[2].

A second element of this OSCM would include the BDCP Implementing Entity, in cooperation with willing non-project diverters, sharing costs to remove, relocate, consolidate, modify design, and alter operations of individual non-project diversions 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 both elements of the OSCM would rely on information from a comprehensive study to be conducted by DFG 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.). Funding for this study is anticipated to come from Assembly Bill 2938[3], which is currently in the State Assembly. If not funded, the BDCP Implementing Entity would fund a similar study to gain this information

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 would be evaluated based on the results of the DFG study discussed above.

For the first element of this conservation measure the BDCP Implementing Entity would enter into a Memoranda of Agreements (MOAs) or similar binding instrument with The Bureau of Reclamation and DFG that would describe respective roles and obligations for expenditure of BDCP funding. Elements of the MOAs would include a description of specific activities that would be funded by BDCP, preparation of annual work plans for BDCP funded activities, provisions for documenting work performed, monitoring responsibilities, and provisions for modifying or terminating the MOA.

The BDCP Implementing Entity in coordination with the Fishery Agencies would be responsible for identifying the diversions to be screened. The Bureau of Reclamation and DFG would be responsible for implementing their respective scopes of work and submitting reports as specified in the MOA that demonstrate that the work plan has been successfully implemented.

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

[2] 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.

[3] If approved, Assembly Bill 2938, currently in the State Senate, would provide three years of funding for a comprehensive DFG study of fish distribution patterns and entrainment rates of at least 27 non-project diversions throughout the Delta (C. Armor pers. comm.).

funding levels, provisions for documenting work performed, access to conduct effectiveness monitoring, and provisions for modifying or terminating the contracts.

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. This conservation measure would also be terminated if Reclamation and DFG choose not to enter into MOAs with the BDCP Implementing Entity. 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 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].
- 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

[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 (see below), 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 the in-channel location of the 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), 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.

Implementation timeframe: It is anticipated that this conservation measure could be implemented in the BDCP near-term implementation period by screening, removing, relocating, consolidating, modifying the design, or altering the timing of diversions already identified as high priorities. Long-term implementation would be responsive to new information developed regarding screening prioritization of particular diversions and to changes in Delta conditions created by physical habitat restoration and changes in operations with dual conveyance.

Implementation considerations: This conservation measure is considered to be practicable because screening efforts already underway have proven effective. Construction and maintenance costs, however, are high ($7500/cfs construction costs for smaller diversions and >$50,000/cfs for larger diversions) and the existing programs require additional funding (D. Meier pers. comm.).

The effectiveness of the conservation measure is dependent on the number of diverters willing to remove, relocate, and consolidate their facilities, which has been historically difficult to obtain. Removal of a legal diversion could be accomplished through acquisition of lands in fee-title or conservation easement from willing sellers, which would result in the cessation of water diversion and removal of individual diversions. Water rights of these diverters would need to be addressed. The removal of illegal diversions could be accomplished through enforcement and other legal remedies.

An important component to the effectiveness of this conservation measure will be the development and application of criteria for identifying which diversions, if removed, relocated, or consolidated, would result in the greatest reductions in non-project entrainment losses of covered fish species.

Relocation of diversions and consolidation of multiple diversions could incur significant costs if substantial additional infrastructure is required to reach a more distant diversion site. Diversion

design modification is considered to be moderately difficult to implement. It would require knowledge of in-channel distributions of covered fish species near the diversion. Regardless, it would likely be much cheaper than screening, relocating, or consolidating diversions. Also, diverters may be more willing to make smaller changes to their diversions than screening, relocating, or consolidating. Altering diversion timing could also be difficult to implement.

The magnitude of effect of this conservation concept is difficult to predict because the effect that non-project entrainment has on covered species is relatively unknown and likely highly variable through space and time. However, the effect is predicted to be larger during times when the species are present in the Delta system. The effect is dependent on the success of real-time monitoring of the presence of covered species and on the ability to discern clear diel or seasonal patterns in fish activity. Seasonal diversion patterns could be affected by the crop type grown by the diverter.

Resiliency to future changes: Because the distribution of covered fish species could change in the Delta with sea level rise, the effect of individual diversions on entrainment of covered species and therefore, effectiveness of screening, relocation, consolidation, design modification, and alteration of timing of diversions could change with future climate change.

Uncertainties and risks: It is difficult to assess the effectiveness of this conservation measure because the effect of non-project diversions on the entrainment of covered species is relatively unstudied. Entrainment is highly variable among diversions. If approved, Assembly Bill 2938, currently in the State Assembly, would provide three years of funding for a comprehensive DFG study of fish distribution patterns and entrainment rates of at least 27 diversions throughout the Delta (C. Armor pers. comm.). If funded, this study would provide needed information on the effects of non-project diversions on covered fish species.

Understanding the effect of variation of parameters related to diversion size, location, pumping patterns, etc. on entrainment rates of covered species would allow better informed decisions regarding priorities for removal, relocation, and consolidation of diversions. Patterns of diel and seasonal activity and distribution of covered fish species would provide necessary information to determine the alterations in timing and location of diversions.

There is evidence that diversions entrain large numbers of non-native species (Brown 1982, Nobriga et al. 2004). Therefore, screening diversions could be more beneficial to non-native fish species than native fish species, potentially increasing competition with and predation by non-natives on natives. Understanding the effect of variation of parameters related to diversion size, location, pumping patterns, and other factors on entrainment rates of covered species would allow better informed decisions regarding screening priorities and would improve screening success for covered species.

Monitoring and adaptive management: With respect to screening actions, the Bureau of Reclamation and the DFG would be responsible for monitoring the effectiveness of their respective fish screening programs in reducing the entrainment of covered fish species at non-project diversions. The BDCP Implementing Entity would review progress and other relevant reports prepared by the Anadromous Fish Screen Program and the Fish Screen and Passage Program. The BDCP Implementing Entity would coordinate with the Bureau of Reclamation and the DFG to screening strategies and funding levels through the BDCP adaptive management process as appropriate based on review of funded program reports.

Prior to relocating or consolidating diversions, the BDCP Implementing Entity would conduct surveys to determine the existing habitat use by covered fish species near the effected diversions and fish use at locations where diversions would be relocated or consolidated. Following completion of a relocation or consolidation, fish use would be monitored in the same locations to determine the effectiveness of the relocation or consolidation in reducing entrainment levels. 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).

Performance Monitoring Metric #1: Number of diversions or capacity of diversions screened, removed, relocated, consolidated, or modified, or with altered operations for fish protection.

Justification: Reducing entrainment mortality of covered fish species will depend on successful screening, removal, relocation, consolidation, modification, and altered timing of non-project diversions.

Target: Successfully modify ___ diversions or ____ cfs of diversion capacity per year.

Adaptive management trigger and response: The BDCP Implementing Entity will review these reports and work in consultation with the responsible entities to evaluate program success and determine if adjustments in funding levels are warranted.

If there are an insufficient number of diverters willing to participate in the program, the BDCP Implementing Entity will work with diverters to determine which changes should be implemented to enhance their willingness, while still providing significant benefit to covered species, thus increasing the likelihood that the alterations will be completed.

Monitoring approach: The responsible entities under the MOAs will prepare annual reports describing the work done with BDCP funds, relating those expenditures to the annual scope of work prepared under the MOA.

Effectiveness Monitoring Metric #1: Entrainment mortality of covered fish species.

Justification: Because reducing entrainment mortality of covered species is the goal of this conservation measure, determining entrainment mortality before and after screening, removal, relocation, consolidation, modification, or altered timing of selected diversions will indicate whether the measure has been successful.

Target: Reduce entrainment mortality of covered fish species in individual non-project diversions by ___%.

Adaptive management triggers and responses: To assess the efficacy of screening changes, the BDCP Implementing Entity would review progress and other relevant reports prepared by the Anadromous Fish Screen Program and the Fish Screen and Passage Program. The BDCP Implementing Entity would coordinate with the Bureau of Reclamation and DFG to adjust screening strategies and funding levels through the BDCP adaptive management process as appropriate is review of funded program reports indicates that target reductions in entrainment mortality are not being met. The BDCP Implementing Entity may adjust its strategies for selecting diversions to be relocated, consolidated, or modified or to have altered operations or adjust funding levels through the BDCP adaptive management process if

monitoring results and other relevant information (e.g., monitoring and research conducted by others) indicate that entrainment mortality is not sufficiently reduced to the defined targets.

Monitoring approach: With respect to screening diversions, the Bureau of Reclamation and the DFG would be responsible for monitoring the effectiveness of their respective fish screening programs in reducing the entrainment of covered fish species at non-project diversions. This would involve monitoring of entrainment mortality before and after the proposed changes to non-project diversions are implemented. With respect to relocating, consolidating, modifying, or altering the timing of diversions, the BDCP Implementing Entity would monitor entrainment mortality before and after the proposed changes to non-project diversions are implemented. Under both monitoring programs, diverted water would pass through a sampling device (e.g., a net) immediately after taken from the channel to enumerate the number of fish entrained.

Reversibility: Reversibility of the screening of diversions is expected to be low due to the large amount of infrastructure associated with screens, particularly for larger diversions. Reversibility of the removal of diversions is expected to be moderately difficult, depending on the extent of facilities removed or modified (versus left in place without operation). Land use changes associated with land acquisition would result in low reversibility. Reversibility of consolidating and/or relocating of diversions is expected to be low or moderate depending on the level of infrastructure modification required. Reversibility of design modifications is expected to be moderately high because modifications could be simple and inexpensive relative to screening, relocating, and removing diversions. Reversing alterations in the timing of diversions is expected to be easily accomplished.

OSCM22: Establish No Wake Boating Zones in Delta Waterways Near Intertidal and Shallow Water Habitat Restored under the BDCP. The BDCP Implementing Entity would coordinate with DBW and local governing entities to establish low boat speeds regulations (no wake zones) and post signs in Delta locations with intertidal marsh and shallow subtidal habitat that has been restored under the BDCP at a funding level of $$_____ over the term of the BDCP. Low boat speed zones would only be established in Delta locations with intertidal marsh and shallow subtidal habitat that has been restored under the BDCP and that are being substantially degraded by boat wakes. The BDCP Implementing Entity would be responsible for undertaking investigations necessary to identify restored areas that would benefit from establishing low boat speed zones.

The BDCP Implementing Entity would enter into Memoranda of Agreement (MOA) or similar binding instruments with DBW and local governing entities that would describe respective roles and obligations for expenditure of BDCP funding. Elements of the MOA would include a description of specific activities that would be funded by BDCP, preparation of annual work plans for BDCP funded activities, provisions for documenting work performed, monitoring responsibilities, and provisions for modifying or terminating the MOA.

The BDCP Implementing Entity would be responsible for developing annual work plans, in coordination with the Fishery Agencies, that specify the location and extent of additional no wake zones to be implemented by DBW and local governing entities at funded levels. DBW and local governing entities would be responsible for implementing the scope of work and submitting reports as specified in the MOA that demonstrate that the work plan has been successfully implemented. DBW and local governing entities would also be responsible for monitoring the effectiveness of additional no wake zones on

covered fish species habitat use and, if necessary, adjusting methods to improve their effectiveness over time.

If results of monitoring indicate that projects implemented under this conservation measure do not substantially and cost-effectively benefit covered fish species, the BDCP Implementing Entity, in coordination with Fishery Agencies, may terminate this conservation measure. The BDCP Implementing Entity, in coordination with the Fishery Agencies, would also terminate this conservation measure if DBW and local governing entities choose not to enter into a MOA with the BDCP Implementing Entity. 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.

Problem statement: The BDCP Conservation Strategy includes multiple conservation measures that would restore intertidal marsh and shallow water habitat (see *Section 3.4.2. Physical Habitat Restoration Conservation Measures*). Boat wakes from recreational boats could damage these restored habitats intertidal marsh habitat and disturb shallow waters in which splittail and salmonids may be rearing or delta smelt may be spawning. DBW and local ordinances currently restrict boat speeds to 5 mph in specific areas of the Delta, such as near boat docks and landings, although these limits have been set primarily for human safety concerns and protection of infrastructure.

Hypotheses: Reducing boat wakes by establishing no wake zones in BDCP restored areas of the Delta is hypothesized to sustain the benefits of intertidal marsh and shallow subtidal habitat described in *Section 3.4.2. Physical Habitat Restoration Conservation Measures*.

Implementation timeframe: It is anticipated that that this conservation measure could be implemented in the BDCP near-term implementation period when intertidal and shallow subtidal habitat restoration begins.

Implementation considerations: This conservation measure is expected to be readily implemented at minimal cost. The measure may not be easily enforceable if there is a substantial extent of waterways in which reduced boat speeds would be posted. An important component to the effectiveness of this conservation measure will be the development and application of criteria for identifying which habitat restoration and fish use areas would most benefit from establishment and enforcement of low boat speed regulations.

Resiliency to future changes: Because the distribution of covered fish species could change in the Delta with sea level rise, locations in which low boat speeds are set may have to be altered with future climate change.

Uncertainties/risks: The effect that boat wakes have on shallow water habitat is unknown and, as a result, the potential benefit of this conservation measure to covered fish species is unknown. The adverse effects of boat wakes on marsh vegetation is well documented (Nordstrom 1992).

Monitoring and adaptive management considerations: ***[Note to reviewers:*** *this section is a general summary; more detail will be provided in future iterations.]* Local law enforcement agencies would be responsible for monitoring compliance of boaters in established low boat speed zones. As part of agreements with DBW, the BDCP Implementing Entity would monitor the effectiveness of slow boat speed zones for improving covered fish species habitat use and habitat conditions. In coordination with DBW, the BDCP Implementing Entity would recommend revisions to low speed zone regulations through the BDCP adaptive management process based on results of effectiveness monitoring.

Reversibility: This conservation measure is expected to be easily reversible.