

1 *[Note to reviewers: This handout presents BDCP conservation measures CM12 through CM19*
2 *that address stressors on the covered fish species that are not addressed by the ecosystem- and*
3 *natural community-level conservation measures. These species level measures address other*
4 *stressors on covered fish species and will be included in Section 3.4.4 Species Level Other*
5 *Stressor Conservation Measures of the Chapter 3, Conservation Strategy. These measures*
6 *provide for actions to address effects of nonnative aquatic vegetation, low levels of dissolved*
7 *oxygen, predator hot spots, illegal harvest, entrainment, water quality, and hatchery practices on*
8 *the covered fish species.]*

9 **3.4.4 Species Level Other Stressor Conservation Measures**

10 This section provides descriptions of species-level conservation measures that address
11 environmental stressors on fish that are not addressed by the ecosystem- and natural community-
12 level conservation measures. These other stressor conservation measures provide for actions to
13 address the effects on covered fish species from predation, low dissolved oxygen, illegal harvest,
14 mercury, and hatchery practices.

15 **3.4.4.1 CM12 Methylmercury Management**

16 The purpose of this conservation measure is to minimize the potential for habitat restoration
17 actions, implemented under the BDCP (CM4 *Tidal Habitat Restoration*, CM5 *Seasonally*
18 *Inundated Floodplain Restoration*, and CM6 *Channel Margin Habitat Enhancement*), to increase
19 the bioaccumulation of methylmercury in covered and other native species. It is also intended to
20 reduce potential negative effects of methylmercury on important native species that maintain
21 natural communities through herbivory, physical disturbance activities, predator-prey
22 interactions, and other species interactions, or through species regulation of ecosystem processes.

23 The BDCP Implementation Office will:

- 24 1) Conduct pre-acquisition surveys to characterize the mercury content in the soil and other
25 factors that could lead to high rates of methylation in potential habitat restoration areas;
- 26 2) After evaluating site characteristics and site conservation goals, prepare habitat
27 restoration designs using measures that, to the extent practicable, will minimize the
28 bioaccumulation of methylmercury in covered and other native species;
- 29 3) Conduct monitoring, to the extent practicable, to provide data that will enable the
30 Implementation Office to track the effects of the restoration actions on the
31 bioaccumulation of methylmercury in covered and other native species; and
- 32 4) Implement adaptive management actions when monitoring data indicate it is necessary, to
33 the extent practicable, to reduce the bioaccumulation of methylmercury in covered and
34 other native species resulting from tidal habitat and floodplain restoration actions.

35 The Implementation Office will coordinate with DWR, DFG, the Central Valley Regional Water
36 Quality Control Board (CVRWQCB), and other entities to identify and implement methods for

1 minimizing the methylation of mercury in BDCP restoration areas and the bioaccumulation of
2 methylmercury in covered and other native species.

3 3.4.4.1.1 Problem Statement

4 There are high concentrations of mercury in the Plan Area due to the continual transport and
5 deposition of historical gold and mercury mining sediment through Delta tributaries. In aquatic
6 systems, anaerobic organisms transform mercury from an inorganic state to a bioavailable and
7 toxic form of mercury (methylmercury). The consumption and bioaccumulation of
8 methylmercury may cause adverse effects to BDCP covered fish and wildlife species.
9 Methylmercury bioaccumulates within individuals and biomagnifies in higher food chain level
10 consumers (CVRWQCB 2010). Biomagnification results in approximately four-fold increases in
11 tissue concentration with each prey-to-predator step up the food chain (Marvin-DiPasquale et al.
12 2007). As a result, toxic effects of methylmercury are manifested strongly in upper trophic level
13 organisms.

14 Most of the covered fish species are exposed to methylmercury primarily through the
15 consumption of pelagic prey, and secondarily through direct exposure to high concentrations in
16 the water column; although the latter is substantially lower than the former (Alpers et al. 2008).
17 In addition to their pelagic food web exposure, white sturgeon, North American green sturgeon,
18 and Sacramento splittail are most likely to be affected by high methylmercury concentrations in
19 benthic prey. These fish species are long lived and thereby may accumulate high levels of
20 methylmercury.

21 Wildlife may be affected by consuming fish or other aquatic organisms that have bioaccumulated
22 methylmercury, or by consuming tidal marsh vegetation that contains methylmercury. Patterns
23 of methylmercury concentration in tidal marsh plant species are complex, as are the grazing
24 dynamics of the wildlife that feed on tidal marsh plants. These factors make it difficult to predict
25 the effects tidal marsh and floodplain restoration actions may have on wildlife species.

26 Effects of dietary methylmercury on fish include, but are not limited to, endocrine and
27 reproductive problems, liver necrosis, brain lesions, and altered behavior that can result in an
28 increased risk of predation. Bioaccumulation rates in fish may depend on a number of
29 environmental factors in addition to methylmercury concentrations in the water column and/or
30 prey (Alpers et al. 2008); these include growth rate (e.g., seasonality with respect to methylation
31 cycles and/or varied prey availability), foraging in habitats (e.g., preferences can result in
32 foraging in areas with increased propensity for methylation), and food web structure (e.g.,
33 temporal and spatial variability in trophic transfer linkages).

34 High concentrations of methylmercury also have negative effects on birds and terrestrial wildlife
35 (Wolfe et al. 1998). Deleterious effects on bird species from methylmercury consumption
36 include reproductive impairment and reduced juvenile survival (Heinz 1979, Evers et al. 2004,
37 Albers et al. 2007, Ackerman et al. 2008). Methylmercury consumption effects on mammals
38 include anorexia, ataxia, and death (O'Connor and Nielsen 1981, Wren et al. 1987).

1 Methylmercury is produced by the bacterial mediated chemical synthesis of inorganic mercury
2 with an organic compound under fluctuating oxidation/reduction conditions. Inorganic mercury
3 is widely distributed throughout the Delta, both from mercury mining in the Coast Range and as
4 a legacy from the gold-mining in the Sierras where mercury was used in the mining process.
5 Conditions most conducive to the methylation of mercury typically occur at shallow depths
6 within inundated sediments but can also occur in anaerobic open water. Methylmercury can be
7 lost to the atmosphere through de-methylation or be buried deeply in sediment. Net methylation,
8 the balance between methylation and de-methylation, is controlled by an extensive set of
9 chemical and biological factors which are not well understood, limiting the ability of current
10 science to predict changes resulting from tidal habitat and floodplain restoration. Even less is
11 known about how methylmercury enters the benthic and pelagic food webs and the rates at
12 which enters. It is also not well understood how or if methylmercury is transferred between the
13 benthic and pelagic food webs.

14 While the data are still being refined and augmented, the general pattern in the Plan Area is that
15 the total mercury and methylmercury of the sediment are not tightly correlated with
16 methylmercury content in fish and clam tissue. Sentinel species tissue concentrations in the
17 Dutch Slough area are among the lowest in the Plan Area despite high sediment concentrations
18 (Grassetti Environmental Consulting 2008). Perhaps the best available data are from the
19 Blacklock dike breach restoration site in Suisun Marsh from 2006-2009 which shows that tissue
20 concentrations of methylmercury in inland silverside (a fish) decreased in adjacent Nurse Slough
21 despite the continual increase of methylmercury in the sediment (M. Stephensen unpublished
22 data). Additionally, the amount of methylmercury generated by existing land use activities is
23 highly variable with waterfowl management actions in Suisun Marsh generating more
24 methylmercury in managed wetlands than is generated in tidal marsh habitat (USDI et al. 2010).

25 Methods for minimizing methylation in sediments are being developed and include capping
26 mercury-containing sediment with uncontaminated sediment (as at the Montezuma Wetlands
27 Restoration Project) and the addition of ferrous iron or activated carbon granules to the sediment.
28 Continued transport of contaminated sediment into and within the Plan Area would likely limit
29 the effectiveness of capping, and the addition of chemicals is experimental and would likely be
30 limited to relatively small areas.

31 3.4.4.1.2 *Hypothesized Benefits*

32 Through the use of appropriate site selection protocols, design measures, construction
33 techniques, and management actions, tidal habitat and floodplain restoration is hypothesized to:

- 34 • Minimize adverse effects of methylmercury on white sturgeon, North American green
35 sturgeon, and Sacramento splittail;
- 36 • Minimize, and potentially reduce, adverse effects of methylmercury on covered wildlife
37 such as salt marsh harvest mouse, Suisun shrew, and California least tern in Suisun
38 Marsh as a result of the conversion of managed wetlands to tidal wetlands;

1 3.4.4.1.3 *Adaptive Management Considerations*

2 Implementation of this conservation measure will be informed through effectiveness monitoring
3 that will be conducted as described in Section 3.6, *Monitoring and Research Program*, and the
4 adaptive management process described in Section 3.7, *Adaptive Management Program*. Results
5 from the long-term monitoring of sentinel species and covered species tissue concentrations of
6 methylmercury and of sediment concentrations of methylmercury will be used to assess the
7 effects of tidal habitat and floodplain restoration on achieving the methylmercury management
8 objective. Effectiveness monitoring results will be used to determine whether tidal marsh and
9 floodplain restoration actions increase tissue concentrations of methylmercury in sentinel and
10 covered fish and wildlife species.

11 The following four types of monitoring and research actions could be implemented to inform the
12 adaptive management program: (1) quantification of existing mercury and methylmercury
13 sources; (2) remediation of mercury source areas; (3) quantification of ecological and human
14 health effects of methylmercury in the system; and (4) testing of possible management
15 approaches. Many of these action areas are being addressed by ongoing efforts through regional
16 agencies, research institutions, and stakeholders, such as characterization of mercury and
17 methylmercury in sediment and biota throughout the Plan Area, evaluation of solutions for the
18 Cache Creek Settling Basin, research on methylmercury flux and bioaccumulation in various
19 Delta environments, and pilot studies on management approaches such as application of ferrous
20 iron amendments.

1 **3.4.4.2 CM13 Nonnative Aquatic Vegetation Control**

2 The BDCP Implementation Office will control the growth of Brazilian waterweed (*Egeria*
3 *densa*), water hyacinth (*Eichhornia crassipes*), and other nonnative submerged and floating
4 aquatic vegetation (SAV and FAV) in BDCP tidal habitat restoration areas. To implement this
5 conservation measure, the Implementation Office will apply existing methods used by the
6 Department of Boating and Waterways (DBW) *Egeria densa* and Water Hyacinth Control
7 Programs. Control methods currently employed by DBW include application of herbicides and
8 mechanical removal. BDCP methods of removal will be dictated by site-specific conditions and
9 intended outcome or goal. Application of herbicides or other means to control SAV/FAV will be
10 timed to eliminate or minimize potential negative effects of SAV/FAV removal on covered
11 species.

12 **3.4.4.2.1 Problem Statement**

13 Although the historical extent of native SAV and FAV in the Delta ecosystem is unknown,
14 invasive SAV and FAV species have recently colonized large areas of the Delta (Brown 2003,
15 DFG 2008a, Ustin et al. 2008) and are continuing to expand into a greater proportion of channels
16 and new areas (IEP 2008b). The widest spread nonnative FAV species, water hyacinth, was
17 introduced into the Delta over 100 years ago, and severe infestations were experienced by the
18 1980s. The majority of the surface cover of SAV detected through the recent use of airborne
19 hyperspectral imagery is Brazilian waterweed, although the SAV vegetation frequently contains
20 a mixture of three invasive nonnative species: Brazilian waterweed, *Potamogeton crispus*
21 (curlyleaf pondweed), and *Myriophyllum spicatum* (Eurasian watermilfoil) (Ustin et al. 2008).
22 Of the 55,000 acres of the Delta surveyed in 2007, SAV cover has been estimated to be between
23 5,500 and 10,000 acres (Ustin et al. 2008). Nonnative SAV and FAV are thought to cause
24 multiple negative effects on the Delta ecosystem, including providing habitat for nonnative
25 predators of covered fish species (Brown 2003, Nobriga et al. 2005), reducing food abundance
26 and feeding ability of covered fish species by reducing light and turbidity (Brown and Michniuk
27 2007), and blocking rearing habitat for juvenile salmon and splittail (IEP 2008a).

28 The DBW Water Hyacinth Control Program, which began in 1982, has been effective in
29 reducing hyacinth from Delta waterways by using chemical and mechanical removal methods.
30 DBW has developed and operated the *Egeria densa* Control Program since 2001 in response to
31 AB 2193, which amended the Harbors and Navigation Code to designate DBW as the lead
32 agency for the control of Brazilian waterweed in the Delta (DBW 2006, 2008). Initially, the
33 program focused control efforts in a number of locations where Brazilian waterweed impeded
34 navigation, tested a range of mechanical and chemical control techniques, and conducted an
35 extensive suite of toxicology and water quality tests and sampling that were required by the
36 terms of its National Pollution Discharge Elimination System permit and under biological
37 opinions issued by USFWS and NOAA Fisheries (DBW 2008). In 2006, DBW concluded that
38 its current approach was not effective at stopping the expansion of SAV in the Delta and

1 proposed expanding the treatment area to sites across most of the legal Delta between 2006-2010
2 and concentrating on Franks Tract between 2006-2008 (DBW 2006).

3 3.4.4.2.2 Hypothesized Benefits

4 Removing nonnative SAV and FAV from tidal habitat restoration areas is hypothesized to
5 provide benefits to covered fish species through the following mechanisms:

- 6 1. Reducing predation mortality on juvenile salmon, steelhead, and splittail by reducing
7 habitat for nonnative predatory fish (see Appendix F, *DRERIP Evaluation Results*). SAV
8 provides relatively high quality habitat for nonnative piscivores and is spread across large
9 portions of the Delta in or adjacent to significant migration corridors and pelagic and
10 subtidal open water habitat for covered species (Figure 3.X). The interior of SAV stands
11 is good habitat for larval and juvenile centrarchids (Brown and Michniuk 2007), whereas
12 adult striped bass forage immediately outside of the SAV bed and feed on juvenile
13 Chinook salmon, steelhead, splittail, delta smelt, and longfin smelt (Stevens 1966,
14 Temple et al. 1998, Nobriga and Feyrer 2007, 2008);
- 15 2. Reducing predation mortality of delta smelt by increasing turbidity levels (IEP 2008a,
16 Appendix F, *DRERIP Evaluation Results*). SAV and FAV are thought to reduce local
17 flow rates and cause suspended solids to precipitate out of the water column, resulting in
18 a localized reduction in turbidity levels (Grimaldo and Hymanson 1999). Increased
19 turbidity is hypothesized to improve the predator avoidance abilities of delta and longfin
20 smelt. In addition, improved turbidity may reduce the hunting efficiency of nonnative
21 piscivores (Nobriga et al. 2005);
- 22 3. Increasing food consumption by delta and longfin smelt by increasing turbidity levels.
23 SAV and FAV are thought to reduce local flow rates and cause suspended particles to
24 precipitate out of the water column, resulting in a localized reduction in turbidity levels
25 (Grimaldo and Hymanson 1999). A reduction in turbidity is hypothesized to reduce the
26 foraging ability of delta and longfin smelt;
- 27 4. Increasing rearing habitat for juvenile salmon (all races), steelhead, and splittail
28 (Appendix F, *DRERIP Evaluation Results*). Dense patches of SAV and FAV physically
29 obstruct covered fish species' access to habitat (IEP 2008a) that would become available
30 with SAV and FAV removal and control; and
- 31 5. Increasing food availability for all covered fish species near removal locations by
32 increasing light levels below vegetation. Phytoplankton growth is hypothesized to be
33 light-limited in the Delta (Cole and Cloern 1984). The presence of SAV/FAV is more
34 light-limiting for phytoplankton growth, through shading, than anticipated increases in
35 water turbidity resulting from SAV/FAV removal. The reduction in light levels near
36 nonnative SAV and FAV are thought to reduce local growth of phytoplankton, which can
37 affect the local abundance of zooplankton that forms the food base for covered fish
38 species near patches of SAV and FAV.

1 3.4.4.2.3 Adaptive Management Considerations

2 Implementation of this conservation measure by the BDCP Implementation Office will be
3 informed through effectiveness monitoring that will be conducted as described in Section 3.6,
4 *Monitoring and Research Program*, and the adaptive management process described in Section
5 3.7, *Adaptive Management Program*. The Implementation Office will monitor the effectiveness
6 of BDCP-funded elements of the nonnative aquatic vegetation control in successfully controlling
7 SAV and FAV. The Implementation Office will adjust control strategies and funding levels
8 through the BDCP adaptive management process as appropriate based on review of program
9 reports.

10 The Implementation Office will use results of effectiveness monitoring to determine if
11 controlling SAV and FAV results in measurable benefits to covered fish species and to identify
12 adjustments to funding levels, control methods, or other related aspects of the program that
13 would improve the biological effectiveness of the program. Such changes, once approved
14 through the adaptive management decision-making process, will be effected through subsequent
15 annual work plans.

16 If results of monitoring indicate that removing and controlling SAV and FAV does not
17 substantially and cost-effectively benefit covered fish species, the Implementation Office, in
18 coordination with Fishery Agencies, may terminate this conservation measure. If terminated,
19 remaining funding would be deobligated from this conservation measure and reallocated to
20 augment funding for other more effective conservation measures identified in coordination with
21 the Fishery Agencies through the BDCP adaptive management process.

1 **3.4.4.3 CM14 Stockton Deep Water Ship Channel Dissolved Oxygen Levels**

2 The purpose of this conservation measure is to maintain dissolved oxygen concentrations above
3 levels that impair covered fish species in the Stockton Deep Water Ship Channel during periods
4 when covered fish species are present. The BDCP Implementation Office will operate and
5 maintain an oxygen aeration facility in the Stockton Deep Water Ship Channel to increase
6 dissolved oxygen concentrations between Turner Cut and Stockton to meet Total Maximum
7 Daily Load (TMDL) objectives established by the Central Valley Regional Water Quality
8 Control Board (CVRWQCB) (2005) (above 6.0 mg/L from September 1 through November 30
9 and above 5.0 mg/L at all times). The existing aeration facility will be modified as necessary
10 and, if necessary, additional aerators and associated infrastructure would be added to optimize
11 oxygen delivery to the river, contingent upon results of an ongoing demonstration project
12 conducted by DWR and effectiveness monitoring during implementation.

13 The Implementation Office will be responsible for developing annual work plans in coordination
14 with Fishery Agencies that specify the extent of dissolved oxygen improvements to be
15 implemented and will be responsible for monitoring the effectiveness of dissolved oxygen
16 enhancement measures in improving dissolved oxygen levels.

17 **3.4.4.3.1 Problem Statement**

18 The Stockton Deep Water Ship Channel has been identified as an impaired waterway by the
19 State Water Resources Control Board because of low dissolved oxygen concentrations during
20 late summer and early fall (CVRWQCB 2005). The combination of low flows, high loads of
21 oxygen-demanding substances (algae from upstream, effluent from the City of Stockton
22 Regional Wastewater Control Facility, and other unknown sources), and channel geometry
23 contribute to low oxygen levels in the Stockton Deep Water Ship Channel (CVRWQCB 2005).
24 The Stockton Deep Water Ship Channel often fails to meet water quality objectives established
25 by the Regional Board for dissolved oxygen (CVRWQCB 2007b). The 7.5-mile low dissolved
26 oxygen area of the ship channel creates a barrier for upstream migration of adult fall-run
27 Chinook salmon and Central Valley steelhead on the mainstem of the San Joaquin River
28 (Hallock et al. 1970). Further, low dissolved oxygen levels can cause physiological stress on and
29 mortality of fish, including Chinook salmon and steelhead (Jassby and Van Nieuwenhuysen
30 2005), and other aquatic organisms (CVRWQCB 2007b). Once spring-run Chinook salmon are
31 re-established in the San Joaquin River under the San Joaquin River Litigation Settlement,
32 dissolved oxygen sags in the Deep Water Ship Channel will likely have similar effects on this
33 run if sags were to occur during their adult migration period (expected to be approximately
34 March-September). In addition, juvenile white sturgeon, which rear in the San Joaquin River,
35 exhibit reduced foraging and growth rates at dissolved oxygen levels below 58 percent saturation
36 (5.8 mg/l at 15 °C) (Cech and Crocker 2002).

37 One potential solution to dissolved oxygen sags in the Stockton Deep Water Ship Channel, a
38 dissolved oxygen aeration system, has been installed and is currently undergoing field testing by
39 DWR. Results suggests that the aeration facility is effective at raising dissolved oxygen levels in

1 much of the channel. Long-term funding for operations and maintenance has not yet been
2 secured and there are currently no mandates by the CVRWQCB that require contributors to the
3 sag to fund the project. Under this conservation measure, the BDCP would share in funding the
4 long term operation and maintenance costs associated with the project.

5 *3.4.4.3.2 Hypothesized Benefits*

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

- 8 • Reduced delay and inhibition of upstream and downstream migration of fall-run Chinook
9 salmon, steelhead, white sturgeon, river and Pacific lamprey, and, once they are re-
10 established in the San Joaquin River, spring-run Chinook salmon (Hallock et al. 1970);
11 and
- 12 • Reduced physical stress and mortality of fall-run Chinook salmon, steelhead, white
13 sturgeon, river and Pacific lamprey, and, once they are re-established in the San Joaquin
14 River, spring-run Chinook salmon.

15 *3.4.4.3.3 Adaptive Management Considerations*

16 Implementation of this conservation measure by the BDCP Implementation Office will be
17 informed through effectiveness monitoring that will be conducted as described in Section 3.6,
18 *Monitoring and Research Program*, and the adaptive management process described in Section
19 *3.7, Adaptive Management Program*. Results from monitoring of dissolved oxygen levels at
20 various distances from the diffuser(s) will be used to assess the performance of the facilities
21 operations at achieving the water quality objective. The Implementation Office will use
22 effectiveness monitoring results to determine whether aeration facility operations result in
23 measurable benefits to covered fish species.

24 Based on review of performance and effectiveness monitoring results, the Implementation Office
25 will adjust funding levels, oxygen diffuser methods, or other related aspects that will improve the
26 performance and/or biological effectiveness of the project through the BDCP adaptive
27 management process as appropriate. Such changes will be effected through the BDCP adaptive
28 management process and would be included in the subsequent annual work plans.

29 If results indicate that the aeration facility does not substantially and cost-effectively benefit
30 covered fish species, the BDCP Implementation Office, in coordination with Fishery Agencies,
31 may terminate this conservation measure. If terminated, remaining funding will be deobligated
32 from this conservation measure and reallocated to augment funding for other more effective
33 conservation measures identified in coordination with the Fishery Agencies through the BDCP
34 adaptive management process.

1 **3.4.4.4 CM15 Predator Control**

2 The purpose of this conservation measure is to reduce local effects of predators on covered fish
3 species by conducting focused predator control in high predator density locations. The BDCP
4 Implementation Office will reduce the local effects of predators on covered fish species by
5 conducting focused predator control using a variety of methods in locations in the Delta that are
6 known to have high densities of predators (“hot spots”).

7 The Implementation Office will examine existing fish monitoring data, bathymetry data, and
8 radio and acoustic tagging study results to determine the locations and causes of predator hot
9 spots throughout the Delta (Figure 3.XX). Locations of hot spots in which focused predator
10 control will occur include:

- 11 1. Old structures in or hanging over Delta waterways, such as pier pilings or other man-
12 made structures, that are no longer functional or have been abandoned but affect flow
13 fields or provide shade (target: 10-20 structures removed per year);
- 14 2. Boats that have been abandoned throughout the Delta (target: 5-10 boats removed per
15 year);
- 16 3. New intake structures of the North Delta Diversions (target: daily focused removal when
17 sensitive lifestages of covered fish species are present);
- 18 4. The deep hole just downstream of the Head of Old River in the San Joaquin River (target:
19 daily focused removal when sensitive lifestages of covered fish species are present.
20 Additional control efforts may be needed in conjunction with operation of non-physical
21 barriers, as described in CM16);
- 22 5. Specific locations in Georgiana Slough, as identified by Fishery Agencies (target: daily
23 focused removal in up to 3 specific locations when sensitive lifestages of covered fish
24 species are present);
- 25 6. Specific locations in Sutter and Steamboat sloughs, as identified by Fishery Agencies
26 (target: daily focused removal of predators in up to 2 specific locations per slough when
27 sensitive lifestages of covered fish species are present); and
- 28 7. Release sites of salvaged fish from CVP/SWP facilities (target: weekly focused removal
29 at each salvage release site when sensitive lifestages of covered fish species are being
30 salvaged).

31 The Implementation Office will use a variety of methods to control predator populations in hot
32 spots, including removal of predator hiding spots, modification of channel geometry, targeted
33 removal of predators, and/or other focused methods as dictated by site-specific conditions and
34 the intended outcome or goal. Preference for which hot spots to address will be given to areas of
35 high overlap with covered fish species, such as major migratory routes or spawning and rearing
36 habitats.

1 Site-specific control plans will be developed in consultation with the Fishery Agencies, and will
2 include expected benefits, methods, and a monitoring design that will provide information
3 necessary to determine the effectiveness of the action.

4 *3.4.4.4.1 Problem Statement*

5 Although a natural part of the estuarine ecosystem, predation in the Delta has been identified as a
6 stressor to BDCP covered fish species (Appendix F, *DRERIP Evaluation Results*). Habitat for
7 fish predators generally consists of a specific suite of attributes that allow them to forage more
8 efficiently, such as dark locations adjacent to light locations or deep pools that allow the predator
9 to hide and ambush their prey. There are multiple locations in the Delta that contain these
10 physical attributes and attract predatory fish that prey upon covered fish species.

11 *Hypothesized Benefits*

12 Conducting localized predator control at hot spots in the Delta using a variety of control methods
13 is expected to reduce local predator abundance, thus reducing localized predation mortality of
14 Chinook salmon (Temple et al. 1998, Lindley and Mohr 2003), steelhead (Temple et al. 1998),
15 Sacramento splittail (Moyle et al. 2004), and delta smelt (Stevens 1966, Thomas 1967, Moyle
16 2002); and possibly longfin smelt (Nowak et al. 2004), green sturgeon (J. Israel pers. obs.), and
17 white sturgeon.

18 Within the Columbia River system, a predator removal program was investigated in the 1980's
19 for the control of juvenile salmonid predators benefiting from the existence of multiple
20 hydropower dams located along this system. The principle predators for juvenile salmonids
21 within the Columbia River are the northern pikeminnow (*Ptychocheilus oregonensis*), and two
22 nonindigenous species: smallmouth bass (*Micropterus dolomieu*) and walleye (*Sander vitreus*).
23 Northern pikeminnow greater than ~10 inches were considered the primary predator of juvenile
24 salmonids in slower moving portions of the Columbia River (i.e., near hydropower facilities).
25 The program, designed to reduce predation rates in these areas utilizing a bounty program, net
26 fisheries, professional fishers, and fishing areas adjacent to hatcheries, was initiated in 1990.
27 The bounty program targets the removal of 10 to 20 percent of the larger pikeminnow to control
28 size classes that have the greatest juvenile salmonid predation rates, while still maintaining a
29 sustained pikeminnow population. By maintaining a sustained pikeminnow population, the
30 program was designed to avoid compensatory responses of other juvenile salmonid predators in
31 the system (smallmouth bass and walleye) filling the void created by pikeminnow removal.
32 Through the first 16 years of the program there were no indications of compensatory responses.
33 In 2006, however, there were possible indications of localized compensatory responses, although
34 there is insufficient data to determine whether there is a system-wide compensatory response
35 (Takata et al. 2007, Van Dyke 2010).

36 Prior to the initiation of this program, Beamesderfer et al. (1996) estimated that approximately
37 16.4 million juvenile salmonids of the estimated 200 million downstream migrants were
38 consumed by northern pikeminnow in the Columbia system. Another study estimated that

1 northern pikeminnow accounted for 10 to 20 percent of juvenile salmonid mortality (as cited in
2 Young 1997). Predation rates are greatest in the vicinity of each of the eight Columbia and
3 Snake River reservoirs (“pools”). Within the John Day pool, it was estimated that a northern
4 pikeminnow exploitation rate of 10 to 20 percent could reduce their predation on juvenile
5 salmonids by 50 percent (as cited in Young 1997). From 1990 through 2008, the Northern
6 Pikeminnow Sports Reward Fishery removed 3.3 million reward-sized (≥ 9 inches) northern
7 pikeminnow from the Columbia system. From 1991-1998, system-wide exploitation rates of
8 northern pikeminnow averaged 11.7 percent (Hankin and Richards 2000). The removal program
9 estimates northern pikeminnow predation has been reduced by 37 percent (Northern Pikeminnow
10 Sports Reward Fishery 2009). Although the program does not provide an estimated annual
11 number of juvenile salmonids “spared” due to predator removal, model estimates for a reduction
12 of 50 percent predation rate range from 5.2 to 8.2 million juvenile salmonids annually (Hankin
13 and Richards 2000).

14 *3.4.4.4.2 Adaptive Management Considerations*

15 Implementation of this conservation measure by the BDCP Implementation Office will be
16 informed through effectiveness monitoring that will be conducted as described in Section 3.6,
17 *Monitoring and Research Program*, and the adaptive management process described in Section
18 3.7, *Adaptive Management Program*. Monitoring will consist of assessing the abundance,
19 distribution, and size of predator species before and immediately after implementation of
20 predator control actions in each hot spot to determine the performance of the action. In addition,
21 potential changes in survival rate of covered species will be monitored using acoustic tagging
22 studies where possible or similar techniques.

23 The Implementation Office, in consultation with the Fishery Agencies, will use results of
24 effectiveness monitoring to determine whether the actions result in measurable benefits to
25 covered fish species, and to identify adjustments to funding levels, methods, or other related
26 aspects of the program that would improve its biological effectiveness. Such changes, once
27 approved through the adaptive management decision-making process, will be effected through
28 subsequent annual work plans. If results of monitoring indicate that the action does not
29 substantially and cost-effectively benefit covered fish species, the BDCP Implementation Office,
30 in coordination with Fishery Agencies, may terminate this conservation measure. If terminated,
31 remaining funding will be deobligated from this conservation measure and reallocated to
32 augment funding for other more effective conservation measures identified in coordination with
33 the Fishery Agencies through the BDCP adaptive management process.

1 **3.4.4.5 CM16 Non-Physical Fish Barriers**

2 The purpose of this conservation measure is to improve the survival of outmigrating juvenile
3 salmonids by using non-physical barriers to re-direct them away from channels in which survival
4 is lower. The BDCP Implementation Office will install non-physical barriers at the junction of
5 channels with low survival of outmigrating juvenile salmonids to deter fish from entering these
6 channels¹. Non-physical barrier placement locations will include the Head of Old River, the
7 Delta Cross Channel, Georgiana Slough, and could possibly include Turner Cut, Columbia Cut,
8 the Delta Mendota Canal intake, and Clifton Court Forebay (Figure 3.__). Other locations may
9 be considered in the future by the Implementation Office if, for example, future research
10 demonstrates differential rates of survival in Sutter and Steamboat sloughs relative to the
11 mainstem Sacramento River, or in the Yolo Bypass relative to the mainstem Sacramento River.
12 Non-physical barriers will include a combination of sound, light, and bubbles similar to the
13 three-component non-physical barrier used in the 2009 DWR Head of Old River Test Project
14 (Bowen et al. 2009). Non-physical barriers will be installed and operated during October to June
15 or when Fishery Agencies monitoring determines that salmonid smolts are present in the areas
16 when barriers are to be installed. Non-physical barrier placement may also be accompanied by
17 methods to reduce local predator abundance described in CM15 above if monitoring finds that
18 barriers attract predators. Barriers will be removed and stored off-site while not in operation (M.
19 Holderman pers. comm.).

20 **3.4.4.5.1 Problem Statement**

21 Juvenile salmonids experience low survival rates while migrating through the Delta towards the
22 ocean. Survival rates vary among routes taken through the Delta (Brandes and McLain 2001,
23 Perry and Skalski 2008, 2009, Holbrook et al. 2009, Perry et al. 2010) as a result of differential
24 exposure to predation, entrainment mortality at state and federal water export facilities and small
25 agricultural diversions, and other factors (SJRG 2006, J. Burau pers. comm.). Survival for
26 routes through the interior Delta was at most 35 percent that of survival for fish remaining in the
27 Sacramento River (Perry et al. 2010). Such low probability of survival when migrating through
28 the interior Delta indicates that significant population level impacts could result if a sizable
29 portion of the salmon population passed through this area. Perry and Skalski (2009) found that
30 19.8 to 34.5 percent of tagged salmon used Sutter and Steamboat sloughs during migration,
31 while 26.7 percent to nearly one-third of the population entered the interior area. Low survival
32 probabilities and high proportions of the population migrating through the interior Delta combine
33 to significantly reduce salmon survival through the Delta during migration. Physical barriers

¹ Previous evidence suggests that, under a non-physical barrier configuration that was effective in deterring salmon smolts, the non-physical barrier was not effective in deterring delta smelt (Bowen et al. 2008). It is currently not known whether this was a result of the configuration (e.g., sound frequency) of the non-physical barrier or the poor swimming ability of delta smelt that was swamped by high flows (Bowen et al. 2008). Reclamation is currently studying whether there are sound frequencies that deter delta smelt (M. Holderman pers. comm.). If demonstrated to be effective in deterring delta smelt and longfin smelt and deemed necessary by the Fishery Agencies, non-physical barriers could also be installed at the mouths of Old and Middle rivers and in Three Mile Slough (if salinity manipulation is not also needed) to deter these species from moving into these channels where survival is thought to be lower when present, as determined by Fishery Agencies monitoring.

1 have been used in the Delta, such as the Delta Cross Channel gates and the rock barrier at the
2 Head of Old River, to prohibit the entry of fish into channels where survival rates are low.
3 Physical barriers are effective at prohibiting entry of salmonids into channels, but also alter flow
4 dynamics in these channels, likely affecting tidal flows, sediment loads, bathymetry, water
5 supply reliability, potential for noxious algal blooms, toxic concentrations, and other water
6 quality parameters. However, operation of non-physical barriers is predicted to cause smaller
7 changes in the physical configuration of the channel, thus reducing flow-related effects, while
8 improving survival of salmonids by deterring them from entering channels with a higher risk of
9 mortality.

10 3.4.4.5.2 Hypothesized Benefits

11 Installation and seasonal operation of non-physical barriers is hypothesized to improve survival
12 of juvenile salmonids migrating downstream by guiding fish into channels in which they
13 experience higher survival rates (Welton et al. 2002, Bowen et al. 2009). The three component
14 non-physical barrier has shown promising results in laboratory experiments on Chinook salmon
15 emulating the Sacramento River/Georgiana Slough flow split (Bowen et al. 2008) and a field
16 experiment on Atlantic salmon (*Salmo salar*) smolts in the River Frome, UK (Welton et al.
17 2002). In addition, preliminary evidence suggests that the three-component barrier was effective
18 in deterring acoustically-tagged Chinook salmon juveniles from entering the head of Old River
19 during a 2009 pilot study (Bowen et al. 2009). Non-physical barriers that utilize only one
20 component, such as sound or light, have demonstrated only limited success in deterring fish
21 during field trials. For example, out of 25 separate single-component sound and light systems
22 placed in 21 different locations in Europe and the United States to affect the behavior of
23 salmonids near water intakes and canals, fewer than 50 percent were effective in altering fish
24 behavior (USBR 2006). The three-component Non-physical Barrier Test Project at the
25 confluence of Old River and the San Joaquin River in the Sacramento-San Joaquin Delta has
26 demonstrated greater success, successfully deterring 81.4 percent of tagged Chinook salmon
27 smolts from entering Old River compared to conditions without the barrier operating that
28 deterred 25.4 percent of tagged salmon smolts (Bowen et al. 2009). Sound is known to affect the
29 behavior of salmonids (Vanderwalker 1967, Knudsen et al. 1992, 1994).

30 3.4.4.5.3 Adaptive Management Considerations

31 Implementation of this conservation measure by the BDCP Implementation Office will be
32 informed through effectiveness monitoring that will be conducted as described in Section 3.6,
33 *Monitoring and Research Program*, and the adaptive management process described in Section
34 *3.7, Adaptive Management Program*. The Implementation Office will conduct and review
35 monitoring to assess the effectiveness of using non-physical barriers. The Implementation
36 Office will use results of effectiveness monitoring to determine whether operations of non-
37 physical barriers result in measurable benefits to juvenile salmonids and to identify adjustments
38 to funding levels, methods, or other related aspects of the program that would improve the
39 biological effectiveness of the program. Uncertainty regarding the potential attraction of

1 predators to non-physical barriers and the effectiveness of barriers in higher flow areas must be
2 resolved. Such changes, once approved through the adaptive management decision-making
3 process, will be effected through subsequent annual work plans. If results of monitoring indicate
4 that operations of non-physical barriers do not substantially and cost-effectively benefit covered
5 fish species, the Implementation Office, in coordination with Fishery Agencies, may terminate
6 this conservation measure. If terminated, remaining funding will be deobligated from this
7 conservation measure and reallocated to augment funding for other more effective conservation
8 measures identified in coordination with the Fishery Agencies through the BDCP adaptive
9 management process.

1 **3.4.4.6 CM17 Hatchery and Genetic Management Plans**

2 *[Note to Reviewers: SAIC is in discussion with hatchery coordinators to determine the funding*
3 *needs for this conservation measure. This measure will be updated as new information becomes*
4 *available via continued coordination.]*

5 The purpose of this conservation measure is to develop and implement hatchery and genetic
6 management plans to minimize the potential for genetic and ecological impacts of hatchery-
7 reared salmonids on wild salmonid stocks. The BDCP Implementation Office will minimize
8 potential adverse effects of hatchery-reared salmonids on wild salmonid stocks by supporting the
9 accelerated development and implementation of Hatchery and Genetic Management Plans
10 (HGMPs) for all state Chinook salmon and steelhead hatcheries in the Central Valley. HGMPs
11 would be implemented to reduce adverse ecological and genetic effects of hatcheries on wild fish
12 and to be consistent with conservation and protection for listed fish species.

13 The Implementation Office will provide funding to:

- 14 • Expand and finalize steering groups for each hatchery HGMP process, in part to aid in
15 determining hatchery function;
- 16 • Support DFG staff and DFG contractors to prepare HGMPs under DFG and NMFS
17 direction;
- 18 • Staff a DFG HGMP Coordinator, a position dedicated to coordinating HGMPs from
19 beginning through implementation. HGMP implementation and adaptive management
20 will be an ongoing task for the life of each hatchery;
- 21 • Staff hatcheries sufficiently to carry out changes necessary to meet ESA requirements,
22 including providing regional support for fishery biologists at each hatchery;
- 23 • Improve efforts to minimize several categories of hatchery impacts including trucking,
24 inter-basin egg transfers, genetic stock management, monitoring (especially hatchery
25 natural proportions and impacts of hatcheries on natural stocks), and conservation
26 hatcheries; and
- 27 • Provide support for staffing and analysis associated with a genetic parental-based tagging
28 system.

29 Funding of these efforts will be higher during development of the plans and should decline as
30 plans are completed. The BDCP Implementation Office will enter into binding Memoranda of
31 Agreement or similar instruments with DFG as described in Section 3. __.

32 **3.4.4.6.1 Problem Statement**

33 Hatchery-reared Chinook salmon and steelhead are believed to have negative effects on wild
34 Chinook salmon and steelhead, including competition for space and food as juveniles and for
35 spawning habitat as adults. Fish reared in hatcheries can be selected for traits that are different

1 from those in nature, such as those that allow them to survive in an artificial, contained
2 environment (e.g., fast growth, large size). This could result in reduced genetic isolation of
3 hatchery fish from wild fish. It is thought that these hatchery fish outcompete their smaller wild-
4 reared conspecifics (individuals of the same species) for food and space in natural waterways
5 (Williams 2006). Also, as adults, straying by hatchery-reared salmon into natural spawning
6 grounds may lead to competition for spawning habitat and genetic introgression, where offspring
7 of wild salmon are “genetically polluted” with hatchery-selected genes, thereby reducing the
8 fitness of wild population (ISAB 2003, Goodman 2005, Hey et al. 2005).

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

14 Although required, the development of HGMPs in Central Valley hatcheries has been slow to
15 date. The following provides a summary of the status of the progress made toward completion
16 of HGMPs at Central Valley hatcheries (M. Lacy pers. comm.):

- 17 • Nimbus Hatchery - Draft HGMPs for both fall Chinook salmon and winter steelhead
18 have been completed. Updates and minor revisions were made during 2008 to initial
19 drafts. Reclamation and DFG staff are currently reviewing subsequent drafts.
- 20 • Feather River Hatchery - Draft HGMPs for spring and fall Chinook salmon and Central
21 Valley steelhead were completed in late 2008. DWR is reviewing the spring Chinook
22 salmon draft HGMP; fall Chinook salmon and steelhead HGMPs are both still in
23 development by consultant staff. Updates and DWR comments are being incorporated
24 into all drafts as appropriate.
- 25 • Mokelumne River Hatchery - A revised draft HGMP for the steelhead program was
26 completed at the end of 2008 and has been reviewed by hatchery staff. A draft HGMP
27 for the fall Chinook salmon is 50 percent complete.
- 28 • Merced River Hatchery - There has been no progress towards beginning work on this
29 HGMP.
- 30 • Coleman National Fish Hatchery and Livingston Stone National Fish Hatchery - All of
31 the necessary HGMP information for Coleman and Livingston Stone National Fish
32 Hatcheries are contained in the 2001 Biological Assessment (plus a subsequent
33 addendum for Section 10 coverage for winter Chinook and amendments to respond to
34 operational changes at Coleman National Fish Hatchery) submitted to NMFS. The
35 Biological Opinion, including updates to the BA, is in process.

1 3.4.4.6.2 Hypothesized Benefits

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

- 4 • Improve the genetics and fitness of wild salmonids (ISAB 2003, Goodman 2005, Hey et
5 al. 2005); and
- 6 • Reduce competition for rearing and spawning habitat and food with hatchery-reared
7 salmonids (Flagg et al. 2000, Goodman 2005).

8 3.4.4.6.3 Adaptive Management Considerations

9 Implementation of this conservation measure by the BDCP Implementation Office will be
10 informed through effectiveness monitoring that will be conducted as described in Section 3.6,
11 *Monitoring and Research Program*, and the adaptive management process described in Section
12 3.7, *Adaptive Management Program*. The Implementation Office will review annual reports or
13 other relevant reports to assess the performance of the HGMP teams in the accelerated
14 development and implementation of HGMPs. The Implementation Office will coordinate with
15 the individual hatcheries to adjust HGMP strategies and funding levels through the BDCP
16 adaptive management process as appropriate, based on review of performance monitoring results
17 and other relevant reports.

18 The Implementation Office will use effectiveness monitoring results to determine whether
19 HGMP development and implementation results in measurable benefits to covered fish species
20 and to identify adjustments to funding levels or other related aspects of the program that would
21 improve the biological effectiveness of the program. Such changes will be effected through the
22 BDCP adaptive management process and will be included in the subsequent annual work plans.

23 If results of review indicate that HGMP development and implementation does not substantially
24 and cost-effectively benefit covered fish species, the Implementation Office, in coordination with
25 Fishery Agencies, may terminate this conservation measure. If terminated, remaining funding
26 will be deobligated from this conservation measure and reallocated to augment funding for other
27 more effective conservation measures identified in coordination with the Fishery Agencies
28 through the BDCP adaptive management process.

1 **3.4.4.7 CM18 Illegal Harvest**

2 The purpose of this conservation measure is to reduce illegal harvest of Chinook salmon, Central
3 Valley steelhead, green sturgeon, and white sturgeon in the Delta, bays, and upstream
4 waterways. The BDCP will provide funding over the term of the BDCP to increase the
5 enforcement of fishing regulations in the Delta and bays to reduce illegal harvest of covered
6 salmonids and sturgeon. The BDCP Implementation Office will provide funds to DFG to hire
7 and equip 17 additional Game Wardens and 5 supervisory and administrative staff in support of
8 the existing field wardens assigned to the Delta-Bay Enhanced Enforcement Program over the
9 term of the BDCP.

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

15 The BDCP Implementation Office will enter into Memoranda of Agreement or similar binding
16 instruments with DFG as described in Section XX.

17 **3.4.4.7.1 Problem Statement**

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

24 **3.4.4.7.2 Hypothesized Benefits**

25 It is hypothesized that enhanced enforcement on poaching will reduce mortality, and potentially
26 increase population sizes, of green sturgeon (Beamesderfer et al. 2007, DFG unpublished,
27 Boreman 1997, D. Tanner pers. comm., DFG 2007b, Appendix F, *DRERIP Evaluation Results*);
28 white sturgeon (Bay-Delta Oversight Council 1995, Boreman 1997, Schaffter & Kohlhorst 1999,
29 Beamesderfer et al. 2007, DFG 2007b, DFG 2008c, M. Gingras pers. comm., Z. Matica pers.
30 comm., CDFG unpubl. data, Appendix F, *DRERIP Evaluation Results*); Chinook salmon (all
31 races) (Bay-Delta Oversight Council 1995, Williams 2006); and steelhead (DFG 2007b, DFG
32 2007c, DFG 2008d, Moyle et al. 2008, Appendix F, *DRERIP Evaluation Results*). Spring-run
33 Chinook salmon are hypothesized to experience the greatest benefit because they are more
34 susceptible to poaching than other runs due to over-summer holding and ease of locating them
35 (Appendix F, *DRERIP Evaluation Results*). Due to the recent establishment of daily bag limits
36 for Sacramento splittail by the Fish and Game Commission, it is hypothesized that this

1 conservation measure will also reduce mortality and potentially increase population size of
2 splittail.

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

6 *3.4.4.7.3 Adaptive Management Considerations*

7 Implementation of this conservation measure by the BDCP Implementation Office will be
8 informed through effectiveness monitoring that will be conducted as described in Section 3.6,
9 *Monitoring and Research Program*, and the adaptive management process described in Section
10 3.7, *Adaptive Management Program*. The Implementation Office will coordinate with DFG to
11 adjust enforcement strategies and funding levels through the BDCP adaptive management
12 process as appropriate based on review of DBEEP annual reports.

1 **3.4.4.8 CM19 Conservation Hatcheries**

2 The purpose of this conservation measure is to establish new and expand existing conservation
3 propagation programs for delta and longfin smelt. The BDCP Implementation Office will
4 support: (1) the development of a delta and longfin smelt conservation hatchery by the USFWS
5 to house a delta smelt refugial population and provide a source of delta and longfin smelt for
6 supplementation or reintroduction, if deemed necessary by Fishery Agencies; and (2) the
7 expansion of the refugial population of delta smelt and establishment of a refugial population of
8 longfin smelt at the University of California, Davis Fish Conservation and Culture Laboratory to
9 serve as a population safeguard in case of a catastrophic event in the wild.

10 The new facility proposed by the USFWS will house genetically-managed refugial populations
11 of delta and longfin smelt (Clarke 2008). Further, the facility will provide fish to supplement the
12 wild population and provide fish stocks for reintroduction, as necessary and appropriate. State-
13 of-the-art genetic management practices will be implemented to avoid hatchery-produced fish
14 becoming genetically different from wild fish. The facility will be designed with the ability to
15 add other species if necessary in the future. Due to space limitations, the facility as planned will
16 consist of two sites: a science oriented genetic refuge and research facility on the edge of the
17 Sacramento River, and a larger supplementation production facility nearby (B. Clarke pers.
18 comm.) (Figure XX). Specific rules will be established to discontinue housing refugial
19 populations of delta and longfin smelt at the hatchery if and when populations of these species
20 are considered recovered by the Fishery Agencies.

21 In addition, the UC Davis Fish Conservation and Culture Laboratory (FCCL) is in need of
22 additional space and funds to expand the refugial population of delta smelt and establish a
23 refugial population of longfin smelt. The FCCL and the Genomic Variation Laboratory (GVL)
24 at UC Davis are and will be, the primary entities developing and implementing genetic
25 management of the delta smelt refugial population over the period 2009-2015 or longer and may
26 then play a secondary role in keeping a back-up population(s).

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

32 The BDCP Implementation Office will enter into binding Memoranda of Agreement or similar
33 instruments with the USFWS and University of California, Davis similar to that described in
34 Section XX. In addition, if and when populations of these species are considered recovered by
35 the Fishery Agencies, the Implementation Office will terminate funding for the propagation of
36 the species and either fund propagation of an additional BDCP covered fish species, if necessary
37 and feasible, or deobligate funds to this conservation measure and reallocate them to augment

1 funding other conservation measures identified in coordination with the Fishery Agencies
2 through the BDCP adaptive management process.

3 3.4.4.8.1 *Problem Statement*

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

11 3.4.4.8.2 *Hypothesized Benefits*

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

- 14 • Provide a safeguard against the possible extinction of delta and/or longfin smelt by
15 maintaining a captive population that is genetically similar to the wild population (Lande
16 1988, Hedrick et al. 1995, Sveinsson & Hara 1995, Carolsfeld 1997, Sorensen 1998,
17 USFWS 1998, 2003, Hedgecock et al. 2000, Kowalski et al. 2006, Turner et al. 2007,
18 Nobriga 2008, Turner & Osborne 2008, B. Clarke, pers. comm., Appendix F, *DRERIP*
19 *Evaluation Results*);
- 20 • Improve the knowledge base regarding threats to and management of delta and longfin
21 smelt by increasing the ability to study the effects of various stressors on these species
22 using hatchery-reared specimens (Appendix F, *DRERIP Evaluation Results*); and
- 23 • Contribute to increasing population sizes of delta smelt (Lande 1988, Deblois & Leggett
24 1991, Sveinsson & Hara 1995, Carolsfeld 1997, Sorensen 1998, USFWS 1998, 2003,
25 Flagg et al. 2000, Richards et al. 2004, Kowalski et al. 2006, Purchase et al. 2007,
26 Nobriga 2008, B. Clarke, pers. comm.) and longfin smelt (Sveinsson & Hara 1995,
27 Carolsfeld 1997, Sorensen 1998, USFWS 1998, 2003, Flagg et al. 2000, Richards et al.
28 2004, Kowalski et al. 2006, Nobriga 2008) to self-sustaining levels in the wild when
29 combined with effective habitat restoration and other measures to improve conditions in
30 their natural environment.

31 3.4.4.8.3 *Adaptive Management Considerations*

32 Implementation of this conservation measure by the BDCP Implementation Office will be
33 informed through effectiveness monitoring that will be conducted for this conservation measure
34 as described in Section 3.6, *Monitoring and Research Program*, and the adaptive management
35 process described in Section 3.7, *Adaptive Management Program*. Based on review of
36 performance and effectiveness monitoring results in USFWS and UC Davis annual reports, the

- 1 Implementation Office, in coordination with Fishery Agencies and UC Davis, will adjust funding
- 2 levels, hatchery operations, or other related aspects that will improve the performance and/or
- 3 biological effectiveness of the program through the BDCP adaptive management process as
- 4 appropriate. Such changes will be effected through the BDCP adaptive management process and
- 5 would be included in the subsequent annual work plans.

DRAFT