An Overview of Habitat Restoration Successes and Failures in the Sacramento-San Joaquin Delta

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Executive Summary

The Bay Delta Conservation Plan (BDCP) proposes to create or restore approximately 150,000 acres of aquatic, riparian and terrestrial habitat in the Delta. Given the astonishing lack of specific details in BDCP's programmatic restoration plan, this report briefly reviews historical habitat restoration projects in the 222,902 acres of existing conservation lands within the Delta in an effort to evaluate the likely success of BDCP's conceptual restoration plan.

Despite numerous restoration projects, there have been few documented successes in the Delta. Many proposed projects failed to move beyond a conceptual stage because of a lack of funding. A number of projects succeeded in acquiring property but failed to secure the funding necessary for implementation. Other restoration projects were constructed but failed because they were poorly conceived or lacked sufficient funding to maintain or adaptively manage the habitat. Even relatively successful projects have too often experienced mixed results and unintended consequences. Cumulatively, the myriad restoration projects have failed to slow or reverse the precipitous decline in the estuary's native pelagic and anadromous fisheries.

The consistent flaw of previous restoration efforts in the Delta has been a failure to adequately meet the habit requirements of native fish. The estuary's native species evolved over many thousands of years in response to existing habitat conditions. And that habitat included adequate physical (flow, residence time, variability, etc.) and chemical parameters (salinity, temperature, turbidity, chemical constituents, etc.), as well as the nutrients necessary for primary production to support renewable fisheries. Upstream diversions and Delta exports have radically altered the Delta's hydrodynamics, which has resulted in a loss of critical flows, less variability, degraded water quality and reduced primary productivity. The yearly export of phytoplankton, the foundation of the aquatic food web, is equivalent to more than 30% of net primary production.

The Delta's altered hydrology has allowed numerous invasive non-native species to become entrenched to the detriment of native communities. A number of fishery scientists have observed that a variable freshwater Delta has been transformed into something resembling an Arkansas lake. Creating more Arkansas lake habitat will simply create more Arkansas lake fish.

Successful restoration of native species requires restoring the conditions under which they evolved and prospered. This entails increasing outflows, mimicking the natural hydrograph, improving water quality, protecting the critical low salinity zone (LSZ) and reducing export of primary productivity. However, these are the essential elements BDCP cannot provide.

Construction and operations of BDCP's north Delta diversion facilities will exacerbate existing poor conditions by decreasing outflow, moving critical LSZ pelagic habitat eastward, degrading water quality and exposing sensitive life stages of listed species to massive new water diversions. As mitigation, BDCP proposes a conceptual and highly speculative plan to restore habitat with uncertain public funding.

Our review of the habitat needs of native species and the history of habitat restoration projects in the Delta reveals that BDCP's optimistic projections of success are unrealistic and not likely to restore native Delta fisheries.

Introduction

The Bay Delta Conservation Plan (BDCP) proposes to increase water supply reliability by diverting the Sacramento River through twin 40-foot tunnels under the Delta for export to the San Joaquin Valley and Southern California. It also proposes creation of approximately 150,000 acres of new habitat in the Delta to restore the estuary and offset adverse impacts from diverting vast quantities of water around the Delta. The costs of tunnel infrastructure will be paid by the state and federal water contractors while the vast majority of habitat restoration costs will be borne by the general public.

The BDCP EIR/EIS analyzes the tunnels to a project specific level, while habitat restoration has only been analyzed at a programmatic level. There are few details on specific habitat restoration projects. Fishery agencies and scientists have bluntly questioned the likelihood that habitat creation will be as successful as claimed by BDCP proponents or whether habitat restoration can realistically offset the projected adverse consequences from increased exports and reduced outflow to San Francisco Bay.

For example, the Delta Independent Science Board, in its review of the Draft BDCP EIR/EIS and Draft BDCP Plan, observed, "Many of the impact assessments hinge on overly optimistic expectations about the feasibility, effectiveness, or timing of the proposed conservation actions, especially habitat restoration"[1] and "Positive and timely benefits of habitat restoration are highly uncertain. Failure to realize these benefits will invalidate the final conclusion of no net negative effect."[2] Likewise, the Panel Review of the Draft Bay Delta Conservation Plan, prepared for the Nature Conservancy and American Rivers said, "BDCP is too optimistic about benefits of tidal marsh and floodplain restoration for smelt, particularly the extent of food production."[3]

The National Marine Fisheries Service, in comments on the Draft EIR/EIS said, "There is too much benefit to steelhead smolts assumed from habitat restoration in the Delta."[4] The U.S. Fish and Wildlife Services wrote, "Scientific literature cited in the plan, new analyses provided by DWR, and conclusions of the independent scientific review panel have reinforced our concern that the BDCP restoration plan has not been carefully thought out and has uncertain prospects for benefiting native aquatic estuarine species, particularly delta smelt and longfin smelt."[5]

Can habitat restoration offset the loss of flow due to diversion of massive quantities of fresh water around the estuary and restore severely degraded fisheries? The U.S. Environmental Protection Agency wrote in commenting on the Administrative Draft EIR/EIS, "There is broad scientific agreement that existing Delta outflow conditions are insufficient for protecting the aquatic ecosystem and multiple fish species, and that both increased freshwater flows and aquatic

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[1] Delta Independent Science Board, Review of the Draft BDCP EIR/EIS and Draft BDCP, May 2014. Page 3.

[2] *Id*. Page A-25.

[3] Mount J., et al., Panel Review of the Draft Bay Delta Conservation Plan, prepared for the Nature Conservancy and American Rivers, September 2013, page 109.

[4] National Marine Fisheries Service, Federal Agency Comments on Consultant Administrative Draft EIR-EIS, July 2013, Page 8.

[5] U.S. Fish and Wildlife Service Staff BDCP Progress Assessment, 2013, Page 7.

habitat restoration are needed to restore ecosystem processes in the Bay Delta and protect T & E fish populations. This includes statements from lead federal agencies."

Indeed, as the U.S. Fish & Wildlife Service testified during the State Water Resources Control Board's 2010 flow hearing, "flow in the Delta is one of the most important components of ecosystem function." Habitat is more than the spatial extent of acreage, and increases in habitat area doesn't ensure increases in habitat quality or functionality. Habitat requires adequate physical (flow, residence time, variability, etc.) and chemical parameters (salinity, temperature, turbidity, chemical constituents, etc.), as well as the nutrients necessary for primary production to support renewable fisheries. Yet, BDCP's principle strategy for fixing the Delta is based on the hypothesis is that increased habitat restoration acreage can substitute for flow.

The BDCP Conservancy Strategy identifies some 222,902 acres of existing conservation lands in the plan area. These include properties managed by conservancies and land trusts, agency restoration sites, designated biological mitigation sites, wetlands owned or managed by agencies or private parties, conservation easements, parks, and lands associated with implementation of HCPs and NCCPs.[6]

Since both the BDCP Plan and EIR/EIS contain few specific details of proposed habitat restoration, this report examines the history of habitat restoration in the Delta in order to provide some guidance on the likely success of future habitat restoration efforts. It summarizes our review of the habitat restoration that has taken place in the Delta over the past several decades with emphasis on habitat values for young Delta and longfin smelt as well as Chinook salmon.

Delta Habitat

Delta native fish species depend heavily on the Delta habitats, especially in drier years when flows are insufficient to move their young downstream to the Bay. Young smelt and salmon rear in brackish water in what is called the Low Salinity Zone or LSZ. This zone is typically defined as 0.5 to 6.0 ppt salinity (or roughly 500-10,000 EC conductivity). Another term referred to as X2 is defined as the center of the LSZ at 2 ppt salinity. After spawning upstream in freshwater, smelt tend to concentrate at X2 by summer. In drier years the LSZ and X2 are found mainly in the Delta in the main rearing period of young of both smelt species from late winter into early summer. The LSZ is important because it provides slightly brackish water, frequently suitable water temperatures, and abundant prey for the young fish. The smelt are pelagic species found predominantly in shoal and open water, and beaches near the open water. It is critically important that habitat be restored and developed within or near the LSZ if the expected benefits to smelt and other pelagic fishes are to be achieved.

Young salmon begin entering the Delta as fry soon after emerging from river spawning gravels from late winter to early spring. Fry and fingerlings (25-75 mm) concentrate in shoreline areas and adjacent margin habitats including tidal marshes, sloughs, and channels. Smolt salmon (80 mm +) are often collected in open channels migrating westward toward the ocean generally in winter and early spring, but are also found feeding in margin habitats. It is important that

[6] Public Draft, Bay Delta Conservation Plan: Chapter 3, Conservation Strategy, Table 3.2-2, page 3.2-20.

habitats be restored and developed along their Delta migration pathways to ensure successful passage from the river to the Bay. BDCP proposes to restore only about twenty miles of channel margin habitat over a span of thirty years.

Delta aquatic habitat has been greatly altered by 150 years of reclamation. The majority of the tidal marsh, slough, and open water habitats were reclaimed or altered by a vast system of levees and connecting sloughs by the second decade of the last century. More recently, two major ship channels were carved through the Delta. It should be noted, however, that the recent precipitous decline in pelagic and anadromous species and the listing of numerous species pursuant to state and federal endangered species acts only occurred after construction of the Central Valley Project (CVP) and State Water Project (SWP) and the diversion of massive quantities of water to the San Joaquin Valley and Southern California.

Between 1930 and 1943, an average of 82% of estimated unimpaired flow reached San Francisco Bay. That has declined to less than 50% in recent years,[7] well below the 75% level identified by the State Water Resources Control Board as necessary to protect public trust resources and estuarine health.[8] The State Board's conclusions on needed flows followed a comprehensive proceeding, mandated by the State Legislature, involving agency and independent scientists, academia, water agencies and pubic interest groups. The California Department of Fish and Wildlife, under a similar legislative mandate, reached similar conclusions.[9]

A number of fishery scientists now refer to the Delta as being in a state of perpetual drought. The number of years of critically low inflow to the Bay has more than tripled to 62% of the time since the 1930s.[10]

The BDCP proposes upwards of 150,000 acres of habitat restoration, focusing primarily on tidal marsh restoration. Tidal marsh is proposed to provide direct and indirect benefits to Delta fish through the food web and as habitat for various fish species or specific life stages. One measure of the potential benefits of this large-scale restoration is to review the past history of restoration in the Delta. Have the various efforts to restore Delta aquatic habitats proved successful? This overview summarizes these restoration efforts and explains how that experience relates to habitat restoration efforts prescribed in the BDCP. But before examining historical habitat restoration efforts, we should consider a few of the inherent uncertainties of restoration efforts.

Uncertainties of Habitat Restoration

Much of the historical and BDCP habitat restoration has been focused on restoring tidal marsh. Recent scientific debate has focused on the relative merits of tidal marsh restoration on the

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[7] Swanson, C., WATER-Freshwater Inflow Indicators and Index, Technical Appendix, State of San Francisco Bay 2011, Appendix B, page 73.

[8] State Water Resources Control Board, Development of Flow Criteria for the Sacramento-San Joaquin Delta Ecosystem, 2010, page 5.

[9] CDFG, Quantifiable Biological Objectives and Flow Criteria for Aquatic and Terrestrial Species of Concern Dependent on the Delta, 2010.

[10] Swanson, C., The Power of Measurement, Part II: Projected Freshwater Inflow to the San Francisco Bay Estuary with the Bay Delta Conservation Plan, Swanson's Blog, NRDC Switchboard, 17 December 2013, page 2.

shallow water and pelagic food web of the Delta. The key questions are whether smelt and salmon young use the tidal marsh habitats, whether tidal marshes contribute to food production in the preferred smelt and salmon open water (pelagic) and channel margins (shoreline) habitats of the Delta, whether restoration projects themselves create deleterious effects, and the uncertainties of funding and actual implementation.

One key BDCP hypothesis is that tidal marshes export nutrients and food web production to adjoining pelagic habitats. However, recent scientific reports question that hypothesis; "Tidal marshes can be sources or sinks for phytoplankton and zooplankton. Most appear to be sinks, particularly for zooplankton" and " Even under the most highly favorable assumptions, restored marshes would have at best a minor contribution of plankton production in smelt rearing areas."[11] Also, "Movement of plankton from a tidal marsh (beyond the immediate area of tidal exchange) is likely to be limited and to decrease strongly with distance. Even under ideal circumstances, plankton in water discharged from tidal marsh cannot greatly affect the standing crop of plankton in large, deep channels. Feeding by clams and other introduced species can further reduce contributions of marsh plankton to open-water food webs."[12] As the Delta Independent Science Board recently wrote, "Whether or not any increases in primary production will be transferred to zooplankton and on to covered species that may reside in the restored area or outside of it is largely unknown."[13]

There is also the looming question of whether the proposed habitat can be created without exacerbating methylmercury problems. As the National Marine Fisheries Service (NMFS) put it, "There is no indication that the kinds of habitat restoration that can meaningfully contribute to estuarine fish viability can be created or restored without also methylating the ubiquitous mercury in the system because the management tools available conflict with these fishes' habitat needs. Minimization of water depth and reduction of turbidity to control mercury methylation conflict with the direct habitat needs of delta and longfin smelt and will in some locations favor invasive species such as sunfishes and water hyacinth. However, minimization of water depth and turbidity will maximize the potential for algal production and algal production will generate dissolved organic carbon (DOC). If, as the ADEIS implies, restoration sites will also be designed to minimize the export of DOC from restoration sites to minimize anoxic conditions (reducing methylation opportunities) these designs will also reduce their potential food web benefits."[14] BDCP found that the preferred alternative would increase mercury concentrations and exceed tissue toxicity thresholds in largemouth bass in the Delta.[15] Increases in mercury loading resulting from habitat restoration projects would exacerbate the problem.

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[11] Mount J., et al., Panel Review of the Draft Bay Delta Conservation Plan, prepared for the Nature Conservancy and American Rivers, September 2013, page 109.

[12] Herbold, B. et al., The Role of Tidal Marsh Restoration in Fish Management in the San Francisco Estuary, 2014, page A-11. http://www.escholarship.org/uc/item/1147j4nz

[13] Delta Independent Science Board, Review of the Draft BDCP EIR/EIS and Draft BDCP, May 2014. Page B-39.

[14] National Marine Fisheries Service, Federal Agency Comments on Consultant Administrative Draft EIR-EIS, July 2013, Page 10.

[15] Bay Delta Conservation Plan, Appendix 8I, Mercury, Tables I-7a, I-15Aa, I-11Ba, I-11Ca, I-11Da.

This issue is not limited to mercury. Marshes are often sinks for organic contaminates like PCBs, PAHs, organochlorine compounds and organophosphate and pyrethroid insecticides. Selenium is a serious problem. NMFS commented on the BDCP EIR/EIS, "An expected increase in contribution of San Joaquin River water to the Delta will increase selenium loading in the Delta, especially in the southern Delta and Suisun Bay where bioaccumulation by bivalves is assured (Stewart et al. 2004). This in turn represents an increased risk of deleterious reproductive effects caused by selenium accumulation in fish and wildlife."[16] BDCP found that the preferred alternative would increase annual average selenium concentration in sturgeon over the existing conditions and no action alternatives.[17]

There is also a serious concern that diverting flow around the Delta and reducing outflow will expand the range of overbite clams, "Finally, only adverse effects are indicated resulting from conservation measures in the context of invasive mollusks. CM1 may increase *Corbula* habitat by moving X2 upriver, assuming greater freshwater diversion. Given that *Corbula* is the more effective trophic competitor with covered planktivorous fish, this suggests degradation of habitat characteristics due to CM1. Restoration involved in CM4 (tidal wetland), CM5 (seasonally inundated floodplain), and CM6 (channel margin habitat) may increase potential benthic habitat for *Corbula* and *Corbicula,* overall exacerbating the impacts of these competitors. Tidal and shallow water habitat restoration, if invaded by *Corbula* or *Corbicula* may result in phytoplankton sinks actually worsening circumstances for fish.[18]

Another example of uncertainties in habitat restoration is the effect on tidal energy. As the Independent Science Board observed, "Tidal energy coming from outside the Golden Gate is another limited resource in the development of habitat in the Delta and its larger estuary. A major effect of many of the proposed habitat restoration activities (as well as potential island failures in the future) is likely to be the changes in tidal amplitude and mixing. This will affect the suitability of certain characteristics for restoration."[19] A number of agencies have expressed concerns that changes in tidal amplitude caused by creation of more open tidal habitat will increase salt intrusion in the Delta.

Given the programmatic level analysis of proposed habitat restoration, there is significant uncertainty that large-scale restoration projects will actually be implemented or implemented in a timely manner. The Independent Science Board acknowledged these concerns in saying, "Construction and flow operations may have impacts immediately, whereas the restoration impacts and benefits may lag a decade or more after construction" and "If proposed habitat restoration actions are not implemented in a timely fashion or are not as effective as assumed in the DEIR/DEIS, then the positive impacts of those actions would no longer be present, and the final assessment of a net positive or no net negative effect would not be valid."[20] They also

[16] *Id*.

[17] Bay Delta Conservation Plan EIR/EIS, Appendix 8M, Selenium in Sturgeon, Tables 8M-2, 8M-3, Page 8M-9.

[18] Delta Science Program, Review Panel Summary Report, Bay Delta Conservation Plan (BDCP) Effects Analysis, May 2012, page 60.

[19] Delta Independent Science Board, Review of the Draft BDCP EIR/EIS and Draft BDCP, May 2014. Page B-17.

[20] *Id,* page B-38.

noted, "The literature strongly suggests, however, that there are significant time lags between construction of a new habitat and its full functionality. This means that the benefits of habitat restoration may not occur for a long time and that the benefits may be too late for some species if negative impacts come first" and "Even if all acres are acquired and restoration actions are taken in a timely manner, whether those actions will deliver the anticipated benefits or not is also uncertain."[21]

The lack of funding commitments for BDCP's proposed restoration projects creates major uncertainties. Habitat restoration is extremely expensive. As we discuss below, many proposed restoration projects were unable to move beyond a conceptual stage because of a lack of funding. A number of projects were able to acquire property but couldn't secure the funding necessary for implementation. Other projects were constructed but failed because they lacked sufficient funding to maintain or adaptively manage the habitat.

What is clear is that populations of native species like salmon, steelhead, Delta and longfin smelt, splittail, threadfin shad, native phytoplankton and zooplankton, and several species introduced in the 1800s like striped bass and American shad are collapsing. In contrast to the rapid decline of native species: populations of recent invasive predatory species like inland silversides, bluegill, largemouth bass and overbite clams; troublesome invasive plants like water hyacinth, arundo, Brazilian waterweed, parrots feather and potamogeton; and less nourishing non-native copepods and mysids are flourishing.

Many scientists have observed that the state and federal project's massive water diversions and altered hydrograph have transformed the Delta into something resembling an Arkansas lake. In fact, the Delta is now home to a number of trophy bass fishing tournaments and Bass Master magazine recently ranked the Delta as the ninth best largemouth and smallmouth bass fishing spot in the entire nation. Creating additional Arkansas lake habitat will not restore the iconic native species of the Bay-Delta estuary.

The preceding examples are only a few of numerous critical comments by independent scientists and agencies regarding the highly speculative and questionable assertions by BDCP that habitat restoration is a magical bullet that will not only mitigate adverse impacts of diverting additional water around the estuary but will also restore seriously degraded fisheries. But these are not the subject and purpose of this review.

Instead, this report focuses on whether historical habitat restoration has met the physical goals and objectives of restoration. The following observations are focused primarily on the direct benefits to salmon and smelt based on four decades of sampling fish in Delta habitats. Are the altered habitats after levee breaching, channel digging, and vegetation planting functioning? Has water quality been sufficient to support fish? Have non-native invasive plants and fish taken over these new restored habitats? Are the habitats right for smelt and salmon?

[21] *Id,* page B-39.

History of Aquatic Habitat Restoration in the Delta

There are dozens of "restoration" sites around the Delta dating back several decades or more. There are even more in San Francisco Bay, which are not discussed in this report. As noted above, BDCP has identified almost 223,000 acres of existing conservation lands in the Delta. The majority of these lands were acquired in the last few decades.

Delta restoration has occurred as mitigation for many large and small development projects throughout the Delta. Levee repair, dredging, dock construction, sand mining, new water intakes, bridges, flow barriers, and the large federal and state water projects have undertaken some form of habitat mitigation.

In the recent decade, restoration has been larger and more formal under directed water project mitigation, multi-agency programs such as the Central Valley Project Improvement Act, Corps Central Valley Flood Control Levee Program, Sacramento and Stockton Port Programs, Delta Wetlands Program (private), the state Delta Levees Program, and the CALFED program. Under the State Water Project, Delta Wetlands Project, Montezuma Wetlands Project, PG&E Delta Power Plant Mitigation Program (HCP), and CALFED programs monies were available for government and non-profits to purchase large-acreage projects such as Sherman Island, West Sherman Island, Twitchell Island, Yolo Bypass Wildlife Area, Big Break, Staten Island, Cosumnes River Preserve, Liberty Island, Stone Lakes NWR, Little Holland Tract, and many other significant areas.

In recent years, water districts have acquired large tracts of property in anticipation of future mitigation needs. The most notable is a 5000-acre portion (including 1,100 acres of wetlands) of the lower Yolo Bypass north of Liberty Island called the Lower Yolo Restoration Project.

However, habitat restoration projects have failed to achieve their stated purpose. They have neither slowed nor reversed the collapse of Delta fisheries. We see little on which to base any optimism that more of the same will lead to different results.

The California Department of Fish and Wildlife has conducted surveys of the Delta's pelagic species since 1959. The Fall Midwater Trawl (FMWT) survey was initiated in 1967, the year the State Water Project began exporting water from the Delta. It samples 122 stations each month from September to December, and the data is used to calculate an annual abundance index of pelagic species. These stations range

Department of Fish and Wildlife
Percent Decline in Delta Fish Population Abundance Indices

Fall Midwater Trawl Survey

Species	1967 v. 2013	Five Year Average 67-71 v. 09-13
Striped Bass	99.6%	98.8%
Delta Smelt	95.6%	89.8%
Longfin Smelt	99.8%	99.4%
American Shad	90.9%	99.4%
Splittail	98.5%	87.7%
Threadfin Shad	97.8%	98.1%

Summer Townet Survey

Species	1967 v. 2013	Five Year Average 67-71 v. 09-13
Striped Bass	98.2%	95.4%
Delta Smelt	94.2%	94.3%

Data compiled by CSPA from CDF&W FMWT and STN annual abundance indices.

from San Pablo Bay upstream to Stockton on the San Joaquin River, Hood on the Sacramento and the Sacramento Deep Water Ship Channel.[22]

The Summer Townet Survey was begun in 1959 and samples striped bass and Delta smelt at 32 stations, ranging from eastern San Pablo Bay to Rio Vista on the Sacramento River and to Stockton on the San Joaquin River. Surveys begin in early June and continue on alternate weeks through August, and the data is used to calculate an abundance index.[23]

The annual abundance indices document the continued one to two orders of magnitude decline of the entire spectrum of native pelagic species in the estuary. The same magnitude declines hold true for the native lower trophic orders that comprise the base of the food web.

Central Valley anadromous fisheries have also not fared well and are far below the doubling levels mandated some 22 years ago by the Central Valley Project Improvement Act, California Water Code and California Fish and Game Code.[24] For example, winter-run, spring-run, Sacramento fall-run and San Joaquin fall-run Chinook salmon are at 5.7, 20, 31 and 25.5 percent, respectively, of legally mandated levels.

[22] http://www.dfg.ca.gov/delta/projects.asp?ProjectID=FMWT

[23] http://www.dfg.ca.gov/delta/projects.asp?ProjectID=TOWNET

[24] http://www.fws.gov/stockton/afrp/Documents/Doubling_goal_graphs_020113.pdf

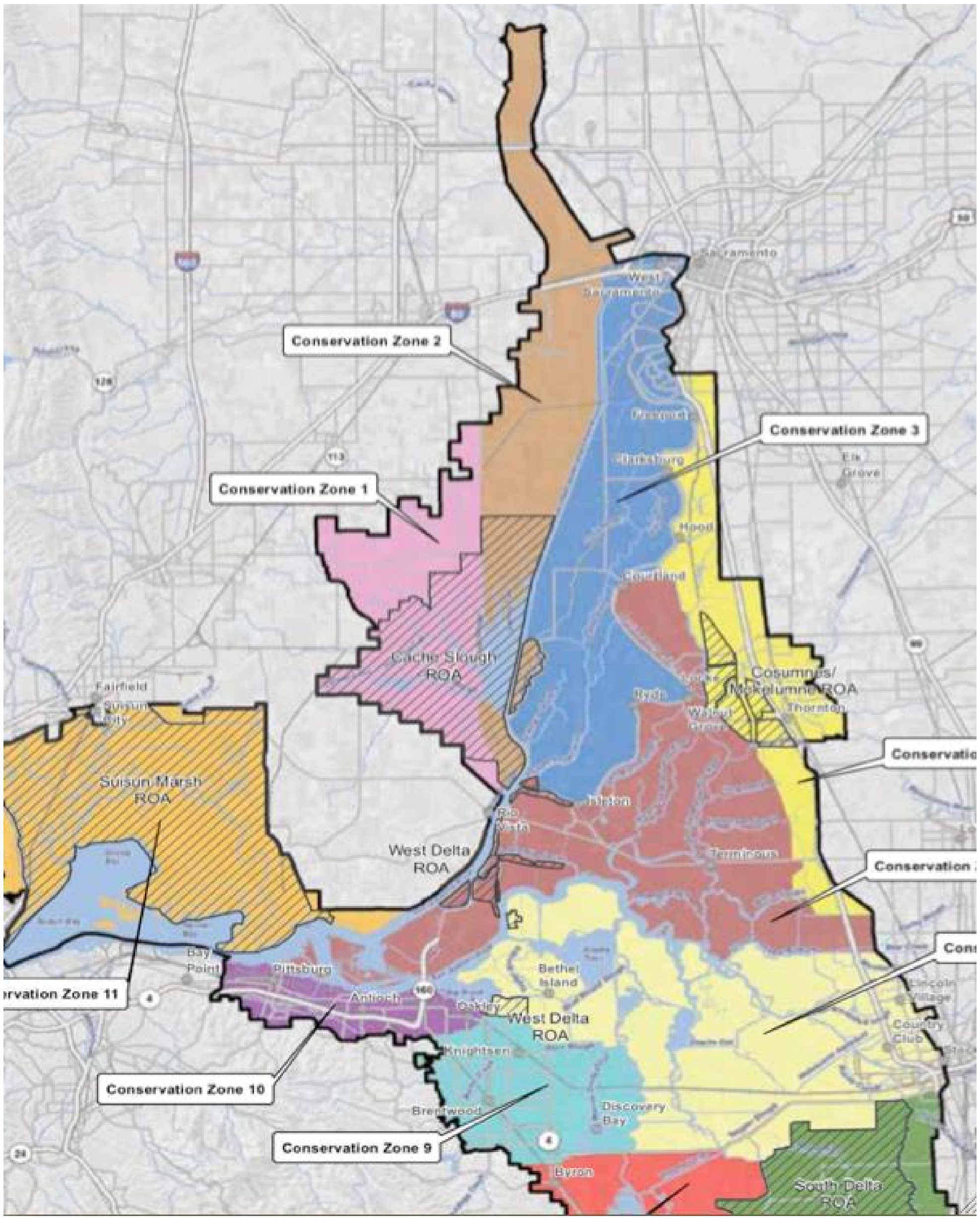

Figure 1. Delta habitat regions as defined in the Bay Delta Conservation Plan. Restoration sites included in the BDCP are shown by cross-hatching.

Geographic Coverage

The focus of this review is on restoration sites in the West, Central, East, and North Delta where habitats are potentially used by smelt and salmon. The South Delta is not addressed primarily because there are few restoration sites and what there is may be of minimal benefit to smelt and salmon. There is discussion of lower San Joaquin River habitat in the discussion of the East Delta, as it is important habitat for salmon and splittail originating from the San Joaquin River system. For consistency, the BDCP Restoration Opportunity Areas (ROAs) are used for the various portions of the Delta. The areas are generally consistent with the BDCP designations (Figure 1), which include more area than the BDCP's Cache Slough ROA. The West Delta region includes the area from Collinsville to Rio Vista, Pittsburg to Antioch, including eastern Chipps Island.

Benefits, Successes, and Failures

This review discusses individual sites including benefits, successes, and failures. Failures include simply doing nothing with the specific properties and letting them deteriorate over time. Failures are common even for active restoration sites where what was built or constructed did not work or actually provided poor habitat. Given the large amount of overall effort and expense, there has been a disturbing lack of progress and overall success. There have been a few successes in protecting or restoring specific sites and considerable research on several of these sites has produced a wealth of restoration and ecological science.

However, what some characterize as new "paradigms" for Delta habitat restoration are, in reality, disasters in the making that jeopardizes both restoration success and the expenditure of billions of dollars. Fish cannot be coerced into thriving under conditions radically different than those in which they evolved over millennia. Restoration projects that fail to provide habitat that reflects conditions under which native species evolved cannot succeed in restoring native species.

West Delta

The West Delta has a rich history of failed habitat "restoration" and missed opportunities. Many of the habitats are managed as part of Suisun Bay/Marsh habitats and are described in the Suisun

Marsh Habitat Management, Restoration and Preservation Plan.[25]

Figure 2. Chipps Island at the western boundary of the Delta on Suisun Bay is a failed mitigation site.

Chipps Island

Chipps Island is a classic example of failed mitigation habitat. The roughly 700 acre "Delta island," at the west boundary of the Delta, has three main parcels: north, west, and east (Figure 2). Each has its own history and habitat characteristics. Today they are duck clubs. The north

[25] http://www.fws.gov/sacramento/outreach/2010/10-29/Documents/Tidal_CM_Chapter_1_Phys_Proc.pdf

parcel was once purchased with mitigation funds by a non-profit but was eventually sold to a duck club for lack of restoration funds. The north and east parcels are muted tidal marshes that are flooded periodically during high tides. But, these are basically managed as freshwater marsh preferred by duck clubs in the Suisun Marsh area. The west parcel would be best described as brackish marsh, as the levees have long been breached and its channel network is fully tidal. The southern boundary of the island on the main ship channel is slowly eroding from ship wakes. Levees have been repaired in recent decades on the north parcel and have gates to allow water to enter the property when needed. Large numbers of native fishes including young salmon have been observed trapped within this parcel's ponds and channels. The island is in need of management and restoration, and the duck club owners have unsuccessfully attempted to sell the property. The island could potentially serve as important winter-spring rearing habitat for salmon and as Delta and Longfin smelt habitat in all but the driest years. However, Chipps Island is a restoration failure in that it should have been restored a decade after it was purchased

with oil-spill mitigation funds.

Figure 3. The Collinsville site along the north shore of the lower Sacramento River channel. Collinsville is left center with Montezuma Island to its right.

Collinsville/Montezuma

Collinsville is at the west boundary of the Delta (Figure 3) and has a rich history. The two islands and most of the lowland shoreline (about 500 acres), at the base of the hills immediately east of Collinsville, were once PG&E property destined for a new Delta power plant.

After efforts to build a new plant failed, PG&E offered the property for restoration as part of the HCP permit mitigation to operate their two remaining power plants in the Delta. PG&E subsequently sold the two plants to Mirant/Southern. The plants are now included within the BDCP package of development actions to be permitted by the new BDCP-HCP process. The Collinsville mitigation site remains in limbo having been once included in the original HCP permit.

However, it was never restored. Title to the property remains with the utility companies and was never transferred to the State, as intended under the original HCP permit. Once a navy base in World War II, the site's tidal channels have filled in with sediment and aquatic plants including invasive submergent aquatic vegetation (SAV) and water hyacinth.

The shoreline on the ship channel is eroding, along with its riparian vegetation. Invasive *Arundo* dominates the two islands. This area was once a designated mitigation site but was never restored as required under the utilities' permits. There is potential for restoration by creating tidal channels and shallow tidal marsh but only if intensive maintenance can control invasive weeds and insure adequate circulation. New permits are being sought under the BDCP without this site being included in the BDCP mitigation package. The BDCP, as an HCP/NCCP, would provide the power plants new ESA take permits, overriding the previous HCP that included the Collinsville site restoration. The new permits would not require the site to be restored. The hills adjacent to the site are now being developed by the utilities as wind farms.

West Sherman Area

The West Sherman area (Figure 4) includes Browns Island (far left), Winters Island (east of Browns), West Sherman (center) and West Island (southeast at right bottom corner).

Figure 4. West Sherman area with Browns and Winters Islands to west, West Sherman and Kimball in center, and Donlon and West Islands at lower right. All restoration opportunities of great potential value that were not included in BDCP. Cities of Pittsburg and Antioch are at lower left and right, respectively.

Browns Island

Browns Island is a 595-acre site generally referred to as "natural" and is part of the East Bay Regional Parks system. It was a reference site for the CALFED Breach study program. It has a dysfunctional tidal channel network with several large dead end channels and limited connection between its marshes and the nearby Bay waters. Its interior waterways are heavily impacted by water hyacinth and parrots feather. The occurrence and density of introduced fishes far exceeds native species. A 2007 report funded by CALFED found that Browns Island was a source of methylmercury production.[26]

Winter Island

Winter Island is a 453-acre private duck club managed as a freshwater marsh duck club with a functional levee system except for its northern tip, which is fully tidal brackish marsh. Its 4.7 miles of riprapped shoreline has unscreened manually operated tidal gates maintain water levels on the island's managed wetlands. Dredge materials from the Stockton Deep Water Ship Channel and various San Francisco Bay dredging projects have been placed on the island to strengthen the levees. As presently configured, the island provides little habitat to the estuary's pelagic or anadromous species and is somewhat of a missed opportunity to restore tidal marsh. Winter Island is 400 acres of "missed opportunity" to restore tidal marsh.

West Sherman Island

West Sherman Island comprises several thousand acres immediately to the west of Sherman Island proper (center of Figure 4). It has large partially disconnected ponds and a slough (dark areas) and is dominated by invasive SAV and invasive floating aquatic vegetation (green areas). It is considered "restored" and is now a state wildlife area. Ship channels are on the north, west, and south sides and its shorelines and remnant levees are slowly eroding from wakes.

The Lower Sherman Island Wildlife Area Land Management Plan states, *"In summer, extensive growth of blue-green algae and aquatic plants can contribute a considerable quantity of organic matter to shallow, dead-end sloughs; this may reduce the level of dissolved oxygen in these locations. Most channels at the wildlife area are clogged with such plant growth." And "Submerged aquatic vegetation within the open water area of Sherman Lake is dominated by the nonnative species egeria. Egeria also dominates submerged vegetation along the shallower margins of the Sacramento and San Joaquin rivers. Large expanses of open water at Sherman Lake are dominated by the invasive nonnative species water hyacinth. This plant readily forms dense, interconnected mats that drift along the water's surface."*[27] *"Mercury contamination is widespread in sediments and waters of the Delta, including at LSIWA.*[28]

The Goals for the wildlife area include, "*Pursue funding and develop plans for identified restoration projects. Cooperate with the development and implementation of local and regional restoration plans for upland and riparian ecosystems by the Ecosystem Restoration Program of the California Bay-Delta Program and other programs that are consistent with the goals of this LMP."*[29]

Lower Sherman Island was originally acquired to establish a public hunting and fishing area. The LSIWMP and CEQA document was finalized in 2007. The project was included as part of

[26] http://mercury.mlml.calstate.edu/wp-content/uploads/2008/10/15_task5_3_browns.pdf

[27] DFW, Lower Sherman Island Wildlife Area Land Management Plan, page ES-5. http://www.dfg.ca.gov/lands/mgmtplans/lsiwa/docs/LSIWA_FinalLMP.pdf

[28] *Id,* page ES-4.
[29] *Id,* page ES-17.

the CALFED Ecosystem Restoration Program Plan and Multi-Species Conservation Strategy. Given a lack of resources, restoration and maintenance have languished and the site is an example of failed restoration efforts. West Sherman Island is not included in the BDCP.

Kimball Island
Kimball Island is a 250-acre site on the south side of West Sherman. It is a "restored" tidal marsh, having been breached and channeled over a decade ago as a wetland mitigation bank. The original network of tidal channels has filled in with sediment and invasive aquatic plants and the SAV accelerate suspended sediment deposition and the reductions in turbidity. The lower turbidity water with abundant SAV is preferentially beneficial to non-native fishes including golden shiner, largemouth bass, sunfishes and silversides and detrimental to some native fishes. Constructed marshes like Kimball with limited tidal circulation are a recipe for backwater habitats dominated by invasive non-native aquatic vegetation and associated non-native fish community. While Kimball remains a somewhat functional tidal tule marsh, these subtidal backwater marshes also tend to have poor water quality in the form of low dissolved oxygen levels that also favor non-native fishes.

West Island to the southeast is a sandspit of dredge spoils with some channels and functional riparian shoreline. Its southern neighbor spoils island has nearly eroded away.

Donlon Island
Donlon Island a 200-acre site at the southeast corner of West Sherman is another "partially failed" restoration site. Its abandoned levee channels have long been clogged with invasive aquatic vegetation and associated non-native fish species. It was developed as a combination dredge spoils and mitigation site by the Corps of Engineers and the Port of Stockton in the 1980s.[30] Donlon Island is another example of a restored marsh with limited tidal circulation, which leads to backwater habitats dominated by non-native aquatic vegetation and fishes. It was in the CALFED Breach study and is not included in the BDCP.

West Island

West Island, to the southeast, is a sandspit of dredge spoils a few channels and some functional riparian shoreline. Its southern neighbor spoils island is nearly gone.

Central Delta

The Central Delta area includes portions of the lower San Joaquin River, Big Break, False River, Dutch Slough, and Old River (including Franks Tract) (Figure 5). These areas are included in the West Delta ROA (see Figure 1).

[30] http://www.fs.fed.us/psw/publications/documents/psw_gtr110/psw_gtr110_i_england.pdf

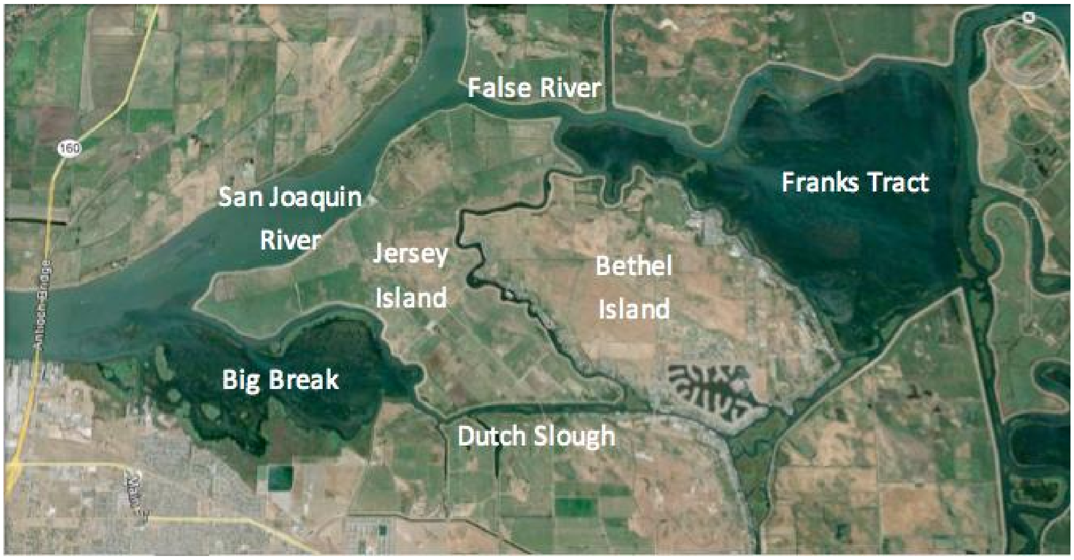

Figure 5. The Central Delta including Big Break at bottom left, Franks Tract at upper right, lower San Joaquin River at upper left, False River at upper center, and Dutch Slough at lower center. Old River runs along the eastern side of Franks Tract.

Big Break

East Bay Regional Park District's Big Break Regional Shoreline Park is located along the south shoreline of Big Break. Once a leveed agricultural property, Big Break's levees failed in 1928 and the 1500-acre shallow bay has remained open since. The bay was once reclaimed marsh along the south shore of Dutch Slough, which connected the central and south Delta with the lower San Joaquin River channel. Today the bay is clogged with non-native invasive aquatic plants with an ecological footprint more like an "Arkansas bass lake". The oil company mitigation site at the west end of the Bay is also entirely dysfunctional, being clogged with invasive non-native submerged, emergent, and floating beds of aquatic vegetation (Figure 6). One of its two breaches is completely clogged with sediment and plants.

Big Break Regional Shoreline is on the northwest shoreline of the City of Oakley in Contra Costa County. In 1999 the U.S. Bureau of Reclamation purchased the 668-acre Lauritzen property that is situated along the west side of Big Break adjacent to the chemical company mitigation site as mitigation for the Rock Slough diversion project for the Contra Costa Canal in the Central Delta. This acquisition almost doubled the acreage of the Big Break Regional Shoreline. The site is described as "*a unique and valuable habitat area for several endangered fish and bird species"* in the East Bay Parks brochure.

The entire Big Break area is a prime example of establishing habitat that favors invasive non-native species over native species. It contains massive concentrations of non-native aquatic plants that dominate the shallow water habitat. Neither of the two mitigation sites at the west side of Big Break has been restored as promised. They remain typical of the "restored" habitats of the Delta that have failed in most respects. Not only are they failed habitats, but they enhance populations of non-native predatory fishes that compete with and prey upon Delta native fishes. The Big Break area is not included in the BDCP.

Figure 6. The west end of Big Break is a failed chemical company mitigation site. Some of the chemical waste facilities can be seen at the lower left. The site is virtually abandoned. Big Break Marina is located at the right.

Dutch Slough

The Dutch Slough Tidal Marsh Restoration Area (Figure 7) lies just to the east of Big Break. The 1,178-acre site is comprised of three parcels, partially separated by Emerson Slough and Little Dutch Slough. In the fall of 2003, the Department of Water Resources completed the purchase with funds from CALFED's now defunct Ecosystem Restoration Program. The project proposes to breech the levees to create large expanses on intertidal tule and/or cattail marshes plus areas of open tidal water, managed marsh and uplands. Construction was scheduled to begin in 2013.

However, when the levees are breeched, the site will likely end up similar to Big Break with poor aquatic habitats dominated by non-native invasive aquatic plants. Another fundamental problem with the site is its location on Dutch Slough. During most of the spring and summer, especially in drier years, Dutch Slough has a net flow to the east toward Old River and the state and federal export facilities in the south Delta. Fish in this area would tend to be drawn to the export pumps. Dutch Slough has been proposed for over a decade as mitigation for development projects in the Oakley area and now for the BDCP. It is not a good site and would provide poor habitat contiguous with Big Break and its non-native predatory fishes.

Figure 7. The Dutch Slough Project consists of breaching levees on the upper center tracts. Dutch Slough is located at top and upper right. Big Break is at upper left. The Contra Costa Canal at bottom center is the southern boundary of the project.

Franks Tract

Franks Tract is owned by the State and maintained as a State Recreation Area. It comprises nearly 4000 acres of tidal aquatic habitat with many of the features of an "Arkansas bass lake". It is infested with non-native invasive aquatic plants. The CALFED Record of Decision (August 2000) identified Franks Tract as a location for one of the programmatic Ecosystem Restoration Program (ERP) actions that was intended to provide improvements in ecosystem restoration, recreation, and Delta water quality.[31] "*The Franks Tract Project is one of several interim actions to address fish and water quality concerns in the near future*."[32]

One possible action was to block False River, its connection to the west with the Lower San Joaquin River. False River receives a strong tidal flood flow from the lower San Joaquin. The inflow of turbid San Joaquin water can be seen in Figure 8. Other options included isolating Franks Tract from the Delta channels, thus eliminating it as a refuge for non-native plants and fishes, and reducing the influx of native fish species from the lower San Joaquin River into Franks Tract and Old River (the eastern boundary of Franks Tract).

Native fishes do poorly in Franks Tract because of the low turbidity and high concentrations of non-native predatory fish that thrive in the clear aquatic plant infested habitat. Unfortunately, nothing has been done to date and Franks Tract restoration is not included in the BDCP mitigation.

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[31] Action 1: Restore Frank's Tract to a mosaic of habitat types using clean dredge materials and natural sediment accretion. Control or eradicate introduced, nuisance aquatic plants." Ecosystem Restoration Program Plan – Strategic Plan for Ecosystem Restoration – Final Programmatic EIS/EIR Technical Appendix July 2000.

[32] http://www.water.ca.gov/deltainit/action.cfm

View of Mildred Island looking south along Middle River with McDonald Island to left and Lower Jones Tract in the distance.

Mildred Island

Mildred Island is a small agricultural island of approximately 1,000 acres that was breached in 1983 and not reclaimed. Like Franks Tract, it is open water habitat dominated by SAV. Nobriga et al. (2005)[33] pointed out that non-native fishes dominate such habitat. Local fishermen have long recognized it as a bass hot spot. No attempt has been made to restore this habitat and the site is not included in the BDCP.

Twitchell Island

Twitchell Island is a 3,516-acre island bounded on the north by Seven Mile Slough, on the east and south by the San Joaquin River and on the west by Three Mile Slough. Eighty-five percent of the island is owned by the State of California. Currently, the island is primarily agricultural land with the major crop being corn. It is the site of a 15-acre experiment by the U.S. Geological Survey to study wherther growing tules and catttails can reverse the soil loss caused by farming. It was also the site of a CALFED funded mercury study where two experimental wetland ponds were created. It was found that both ponds were sources of methylmercury production.[34]

However, Twitchell Island does contain a success story. In 2005, the Twitchell Island Reclamation District (RD 1601) constructed and planted approximately 2,100 linear feet of setback levee to increase levee stability and provide 3,000 linear feet of shaded riverine aquatic habitat and 1.4 acres of emergent freshwater marsh habitat along both sides of a back channel off the San Joaquin River.[35] The site (Figure 9) has remained stable and functional after more than a decade. Though small, it is one of the few successes for restoring natural shoreline habitats along Delta levees. The small setback levee provides a small tidal slough with connections to the San Joaquin River, as well as prolific riparian plant community. No specific projects of this type were proposed in the BDCP.

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[33] http://www.dwr.water.ca.gov/aes/docs/Nobriga_etal_2005.pdf

[34] http://mercury.mlml.calstate.edu/wp-content/uploads/2008/10/12_task5_3a_twitchell_final.pdf

[35] http://www.water.ca.gov/floodsafe/fessro/environmental/dee/twitchellsetback.cfm

Figure 8. The Twitchell Island setback levee project is located along the lower San Joaquin River on the south side of Twitchell Island at the center of the photo. It consists of a small tidal channel and island connected at several locations with the river.

North Central Delta

The north-central Delta is also part of the BDCP's designated West Delta ROA. The north-central Delta is sometimes described as the north Delta, as it includes the north of the "interior" Delta in the lower Sacramento River on the north side of Sherman Island.

Decker Island

Decker Island is a 648-acre island that was created between 1917 and 1937 when the Sacramento Ship Channel was dredged out and more than 30 million tons of dredge spoils were placed on top of existing wetlands. The island retains much of the original dredged sediment and has a spoils easement for U.S. Army Corps of Engineering dredging material. D.I Aggregate management LLC owns approximately 473 acres and, as seen in Figure 10, operates a large sand-sediment mining operation on the island. The Port of Sacramento owns approximately 140 acres.

The California Department of Fish and Wildlife purchased 34 acres in 1999 and, in conjunction with the Department of Water Resources, created a 26-acre wetland.[36] The restoration site was constructed similarly to the Kimball Island site by digging out interior channels and connecting them to the Sacramento River via a single breach. This design fails as it creates a dead-end slough system that clogs with aquatic plants (Figure 11) and provides habitat for non-native fish species. By 2003, over 90% of the tidal channels were clogged with water hyacinth (Rockriver, 2003, p. 91).

[36] http://www.water.ca.gov/floodsafe/fessro/environmental/dee/decker.cfm

Figure 9. Decker Island in the lower Sacramento River. The entrance to Three Mile Slough is at upper right.

Figure 10. Mosaic of Decker Island State Wildlife Area development at north end of island. Channels dug have eventually filled with sediment and non-native aquatic plants (light green areas are predominantly water hyacinth). (DWR figure)

Figure 11. The southeast portion of Decker Island. Dark areas are invasive Egeria, while the light green are non-native aquatic plants including water hyacinth. Light brown is interior muted tidal marsh. The light tan between marsh and shoreline is remnant sand levee. The channel at right is the original Sacramento River channel.

Dead end tidal channels like the Decker and Kimball (see Figure 4, above) projects fill with submerged aquatic plants that strain the fine sediments for the water resulting in clear water favored by non-native fishes and avoided by many native fishes including Delta smelt. The dark channels in Figure 11 indicate clearer water than the turbid river. The site also has riparian plantings along its river shoreline, which are generally functional sandy beaches.

The southeastern portion of the island consists about 200 acres of "natural" shoreline used for pasture grazing (Figure 12). This site was once slated for CALFED restoration as it has a low elevation and much potential for tidal marsh-slough habitat. The black areas seen in Figure 12 are nonnative submerged aquatic plants, probably egeria, with the lighter green being other invasive aquatic plants including water hyacinth inshore. Decker Island restoration is included in the BDCP (see Figure 1), although no specific design is provided.

Sherman Island Levee Setback Project

The Sherman Island Levee Setback Project was constructed a decade ago by the Sherman Island Reclamation District (RD 341). The project consists of approximately 6,000 linear feet of setback levee to increase levee stability and provide 6.87 acres of intertidal channel margin habitat and 1.68 acres of riparian scrub shrub along Mayberry Slough (adjacent to Donlon Island site). The project is another example of mitigation provided by the State for the Delta Levees Program. Like the Twitchell Island setback project, this project was successful in restoring a narrow band of riparian and intertidal shoreline habitat along a Delta channel that has been sustained for over a decade on what was otherwise 100% unvegetated rock riprap.

Figure 12. The Sherman Island Levee Setback Project is shown on the southwest shoreline of Sherman Island on Mayberry Slough across from Donlon Island as a narrow strip of green on a new near-white rock levee.

North Delta

The North Delta is the northern component of the North Delta Arc of fish habitat connecting Suisun Bay/Marsh ROA with the Cache Slough ROA via the lower Sacramento River (see Figure 1).[37] The Cache Slough ROA is the BDCP component of the North Delta. It includes Liberty Island, Little Holland Tract, Cache Slough, Lindsey Slough, Barker Slough, Prospect Island, and the Sacramento Deep Water Shipping Channel (Figure 14). This area is considered the new "paradigm" for Delta restoration and thus is a key focus of the BDCP mitigation package.

The area has several features that potentially make it "good habitat." Bypass floods wash it clean several times a decade; it is a back water with long residence time except in floods, and it is a perfect elevation for shallow turbid water and intertidal habitats preferred by many Delta native fishes.[38] The area also has several negative features: low freshwater inflow, high nutrient loadings, and warm summers. Much of the area generally reaches lethal water temperatures for Delta smelt (25C/77F) in summer, particularly in heat waves.

Liberty Island, Little Holland Tract, Little Hastings Tract, and Prospect Island were once leveed reclaimed agricultural lands in the lower Yolo Bypass/Cache Slough region of the Delta. Over the decades all the island levees failed and breached and were subsequently purchased by the government and left for Mother Nature's tides and Bypass floods. Liberty Island is the largest of the reclamations at about 5000 acres. The tides flood all but about 1000 acres of the northern portion of the island. The middle and lower portions of the island are subtidal. The lower

37 http://californiawaterblog.com/2013/10/26/north-delta-arc-lifts-hope-for-recovery-of-native-fish/
38 http://www.water.ca.gov/aes/docs/Sommer_Mejia_SFEWS_Smelt_Habitat_2013.pdf

several thousand acres remain open water connected to Cache Slough. Tules invaded the intertidal habitats of the flooded islands early, but tule expansion has since been limited.

Figure 13. Cache Slough – Lower Yolo Bypass region of North Delta. Lindsey/Barker sloughs are at lower left. Upper Cache Slough is at upper left. Sacramento Deep Water Ship Channel is at right edge. The flooded islands including Liberty (center) and Little Holland Tract (upper center right) of the lower Yolo Bypass are at center right. Prospect Island is east of Ship Channel at lower right.

The shallow waters with long residence time with abundant nutrients and sunshine make the open waters around Liberty Island very productive. The areas relatively high turbidity, mainly from wind-wave erosion along with periodic flood scouring, limit invasive rooted aquatic plants. The aquatic habitat of the area including the Ship Channel appears ideal for Delta smelt and other native Delta fishes.[39]

The 200 acres of northern Liberty Island have been "restored" as a Delta smelt conservation bank with credits being sold for Delta smelt mitigation (Figure 15). Channels have been dug in

[39] http://www.water.ca.gov/aes/docs/Sommer_Mejia_SFEWS_Smelt_Habitat_2013.pdf

uplands area to create slough and marsh habitats. The channels are connected to Liberty Slough and the main open waters of Liberty Island.

Figure 14. Upper Liberty Island (left center) and Little Holland Tract (right center). Ship Channel is at right. Stair-step levee remnants and Liberty Slough are north boundary of Liberty Island. Dark aquatic vegetation is tules. Light green is invasive non-native yellow primrose (able to take hold in the lee of high remnant levees). North staircase sections have brown upland habitats. Liberty Island Conservation Bank is upper right staircase with manmade channels and lowlands excavated from uplands. To the north of Liberty north or Liberty Slough is Yolo Ranch, which is also slated for BDCP mitigation.

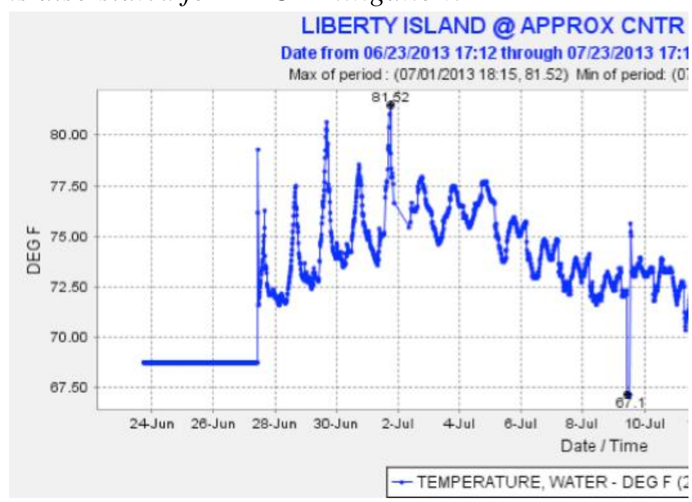

Figure 15. Water temperature during early summer 2013 at Liberty Island. (Source: DWR CDEC)

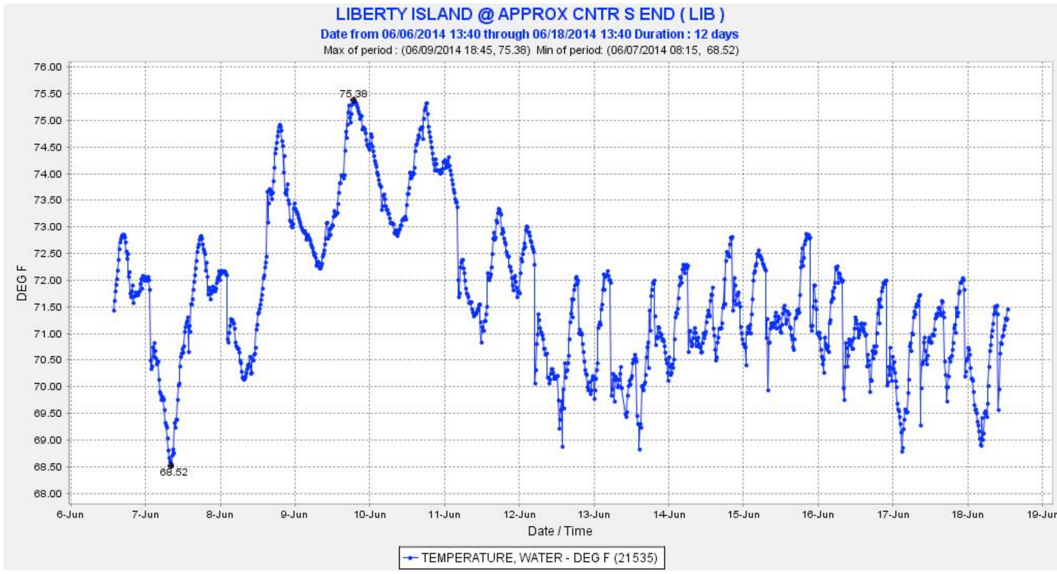

Figure 16. Water temperature during late spring 2014 at Liberty Island. (Source: DWR CDEC)

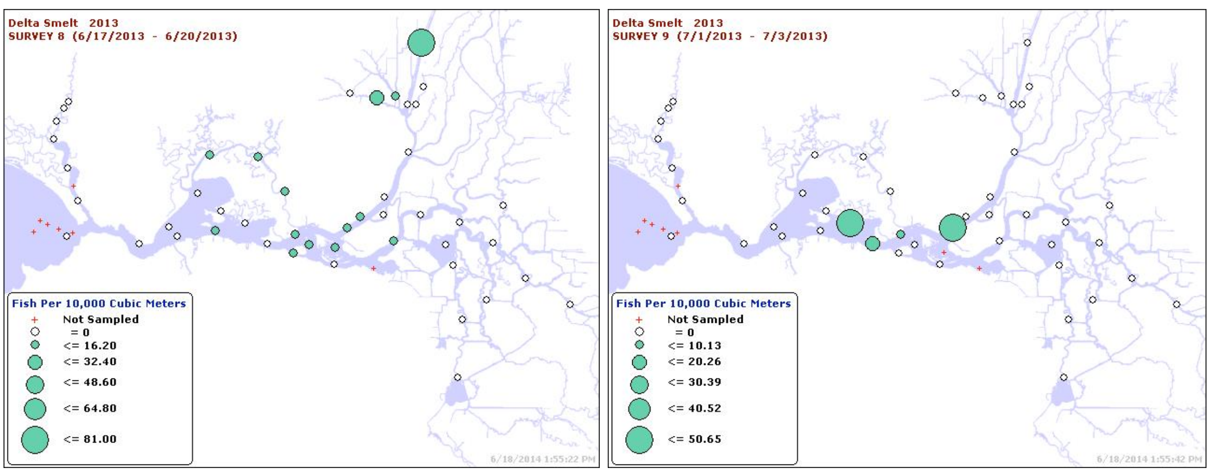

Figure 17. Comparison of Delta smelt distributions in early summer 2013 20-mm surveys before and after heat wave at beginning of July. Note the concentration of smelt in Cache Slough area before the heat wave and the lack of smelt in that area after the heat wave.

The main problem with the Cache Slough area is its periodic warm water temperatures as seen in Figures 16 and 17. With water temperatures generally considered lethal for Delta smelt above 75F, the area is basically inhospitable in summer for smelt. If not for the regular occurrence of the "Delta Breeze", the entire area would only be suited for non-native catfish and carp. Though there may be periodic refuge for smelt in deeper channels of Cache Slough and the Sacramento Deepwater Ship Channel (SDWC), there has been little study of the ability of smelt to use these deep-water refuges and successfully survive the summer of warm dry years like 2013 (Figure

18). While Summer Townet Survey collected some Delta smelt in the Ship Channel in July surveys, none were collected in August surveys.[40]

Recent surveys of the Ship Channel by CDFW question the ability of Delta smelt to survive the summer: "*While the extent of SDWC usage by delta smelt is still unclear, these surveys have shown that delta smelt are limited in their ability to utilize the SDWC year round*."[41]

The Cache Slough complex experiences frequent toxicity from agricultural and urban discharges of chlorpyrifos and pyrethroid insecticides to copepods on which Delta smelt feed and to invertebrates in general. High temperatures tend to increase the toxicity of pyrethroids.[42]

Figure 18. Prospect Island is located between the Ship Channel and Miners Slough. The lower 300 acres are a Port mitigation area. The northern 1600 acres are owned by DWR and intended as a BDCP mitigation site.

Lower Yolo Restoration Project

The Lower Yolo Restoration Project is a proposed tidal restoration project by the State and Federal Water Contractors Water Agency to partially fulfill the habitat restoration requirements of the biological opinions for the Operations Criteria and Plan (OCAP) of the state and federal water projects. It would also help meet restoration objectives of BDCP. The project is located on a 3,795-acre site to the west of the Sacramento Ship Channel and to the north of Liberty Island and would result in the creation of approximately 1,226-acres of perennial emergent marsh (tidal) wetlands and 34-acres of non-tidal marsh.

The proposed enhancement of tidal wetlands at Yolo Ranch to the north of Liberty Island as well as breaching of leveed lands along Cache Slough (see Figure 15) would increase the area of shallow open waters that would warm in the summer sun to levels lethal to Delta smelt. This is a concern as the Sacramento Ship Channel and the general Cache Slough provides habitat for the northern spawning population of Delta smelt. The creation of additional open water will likely increase the amount of seawater that enters the Delta, leading to increased violations of salinity standards

[40] http://www.dfg.ca.gov/delta/data/townet/

[41] https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=30643

[42] Weston, DP. et al., Urban and agricultural pesticide inputs to a critical habitat for the threatened delta smelt (Hypomesus transpacificus), Environ Toxicol Chem, 2014.

and expansion of the overbite clam and a resulting reduction in estuarine food availability. The site will also likely become a net sink for phytoplankton and zooplankton.

The project will likely become a net producer of methylmercury, and even if MeHg is not exported it will tend to bioaccumulate in resident and migratory species. Further, the area will be highly vulnerable to colonization by invasive weeds that will require extraordinary and expensive long-term management to control, something that has not been evidenced by the vast majority of habitat restoration efforts in the past.

Project implementation will likely go forward but, like numerous previous restoration projects, is likely to create unintended and detrimental impacts.

Prospect Island

Prospect Island is located between the Ship Channel and Miners Slough east of Liberty Island (Figure 19). Prospect Island was once a leveed farmland likes its neighboring tracts. Its lower end became a mitigation site for the Port of Sacramento. The upper portion failed in the recent decade and flooded, stranding thousands of fish. The island has since been purchased and levees repaired by the state with intention of the site being part of the BDCP mitigation package. DWR acquired the northern 1,300 acres from the U.S. Bureau of Reclamation in 2010, which had purchased the property in 1994 for restoration purposes that never occurred. The Port of West Sacramento owns the southern 300 acres and has used it for dredge spoil placement.

The Prospect Island Tidal Habitat Restoration Project is a component of the Fish Restoration Program Agreement (FRPA) comprised of a joint effort by the California Department of Water Resources (DWR) and the California Department of Fish & Wildlife (CDFW) to restore the property to freshwater tidal wetland and open water (subtidal) habitats to benefit native fish and improve aquatic ecosystem functions. "*Restoration will entail interior grading, vegetation management, possible clean fill import for subsidence reversal, possible weir installation, breaching of exterior levees, and addressing various property considerations. Monitoring will take place as part of a science- based adaptive management plan. The design of future restoration projects will incorporate knowledge gained through the implementation and monitoring of this project*."[43] Planning and design is expected to be completed by late 2015, with construction commencing by early 2016.

Restoration of the site is complicated by local seepage problems for agricultural lands to the east of Prospect. Full tidal access to the northern portion of the island would result in extensive open water, not unlike Liberty and Little Holland Tract (Figure 20). However, without the scour provided by periodic Bypass floods, upper Prospect like lower Prospect would likely become infested with non-native invasive aquatic plants. Additionally, hydrodynamic modeling shows that open water restoration projects have the potential to increase seawater intrusion into the Delta. Flooding the island also has the potential to increase soil saturation and impact neighboring islands because of the horizontal sand lens that runs under the islands. Restoration might result in the island becoming a net exporter of methylmercury.

[43] http://www.water.ca.gov/environmentalservices/frpa_prospect_restoration.cfm

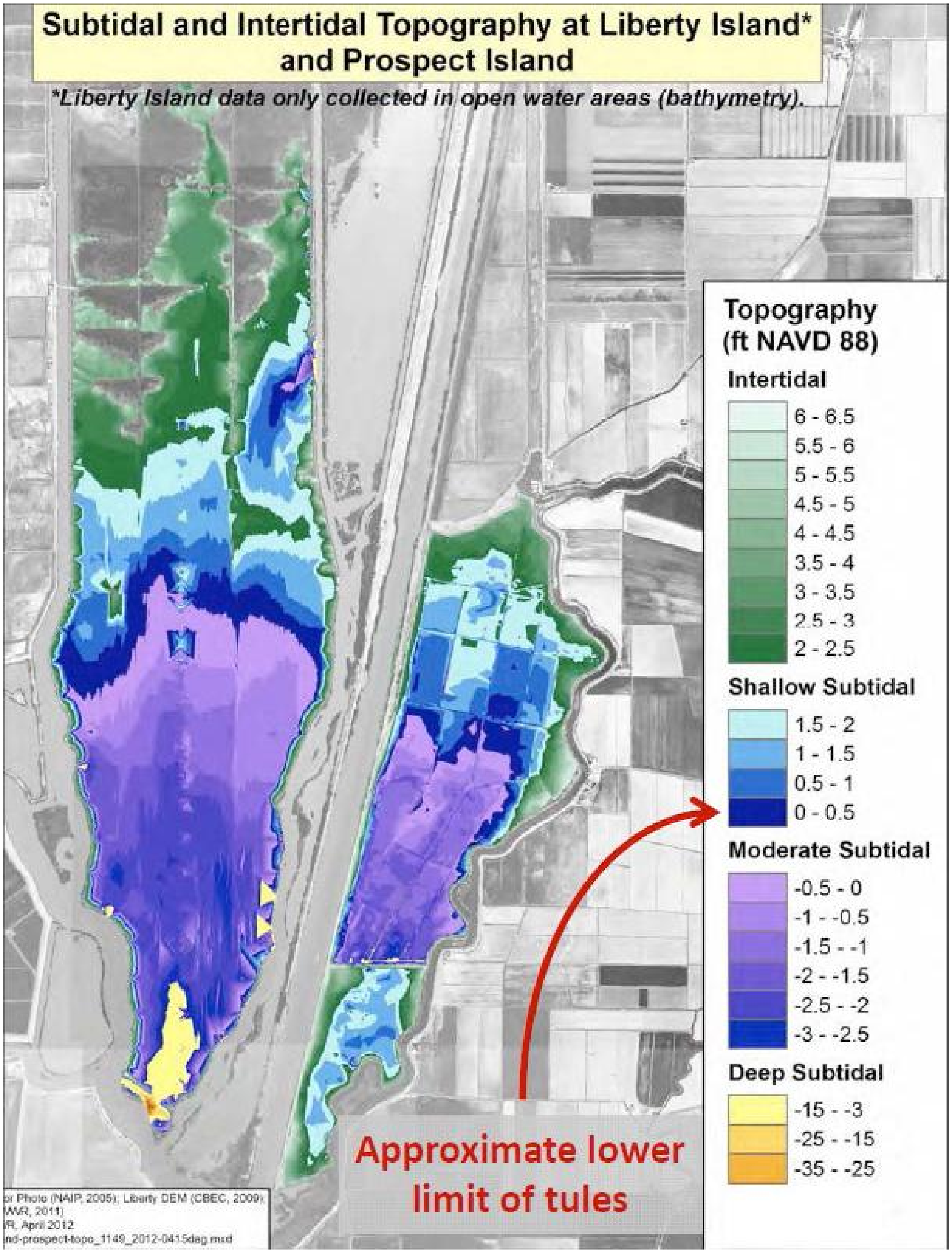

Figure 19. Liberty-Prospect area project water elevations.[44]

The lower island mitigation site is entirely dysfunctional as native Delta fish habitat because of the lack of circulation and dominance of invasive non-native aquatic plants. As seen in Figure 19, the open waters lack turbidity (dark color) and provide habitat more suited for non-native

44 http://www.delta.ca.gov/res/docs/meetings/2013/2013%20DC%20Board%20Mtg_Prospect_FINAL.pdf

warm water fish species. Miners Slough reached 77F during the early July 2013 heat wave and early June 2014 heat wave. More shallow open water habitats would increase warming of the area.

Upper Yolo Bypass

An example of a restoration project that has been largely beneficial with significant unresolved and potential adverse impacts is the Yolo Basin Wetlands Project. And it should be kept in mind that this project, coupled with all of the other restoration projects implemented over the last 30 or 30 years in the estuary, has not reversed the precipitous decline of the Delta's pelagic and anadromous fisheries.

The Yolo Bypass is seasonal floodplain to the west of Sacramento that typically floods in about 60% of years, when winter and spring floodwaters enter from the Sacramento River and several small streams. The floodplain appears to be particularly good spawning and rearing habitat for splittail and young Chinook salmon. The Bypass supports 15 native and 27 non-native fish species. The Yolo Basin Wetlands Project comprises 2,223-acres of seasonal wetlands and 185-acres of perennial wetlands and was dedicated in 1997.[45] Potential enhancements that have been discussed include additional wetlands, fixing fish passage and stranding problems and increasing the frequency of floodplain inundation in drier years.

Measures to address fish stranding in the Bypass were proposed by the Anadromous Fisheries Restoration Program in 1995, by the CALFED Record of Decision in 2000 and the National Marine Fisheries Service OCAP Biological Opinion in 2009, but never occurred. In 2011, biologists documented the stranding of hundreds of listed green sturgeon, spring-run Chinook salmon and steelhead trout in the Bypass. In July 2013, National Marine Fisheries Service biologists estimated that the numbers of stranded endangered winter-run Chinook salmon could be as high as half of the year's returning population.[46] BDCP proposes to facilitate additional periods of inundation and address the stranding issue.

The area is a net producer and exporter of methylmercury. For example, The State Water Board has found that when the Yolo Bypass is flooded, it becomes the dominant source of methylmercury to the Delta.[47] Restoration actions that lead to an increase in wetting and drying periods could exacerbate existing mercury problems.[48] A 2010 report of a study funded by the Central Valley Regional Water Quality Control Board to evaluate methylmercury cycling and export from agricultural and natural wetlands in the Yolo Bypass found that periodic flooding of

[45] http://www.water.ca.gov/aes/docs/Yolo_Fisheries_Paper_2001.pdf

[46] http://calsport.org/news/?s=winter+run+stranding

[47] State Water Resources Control Board, 2009 Periodic Review of the 2006 Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin River Delta Estuary, adopted resolution 2009-0065, page 29. http://www.swrcb.ca.gov/waterrights/water_issues/programs/bay_delta/periodic_review/docs/periodicreview2009.pdf

[48] Foe, C., et al., Task 2: Methyl mercury concentrations and loads in the Central Valley and Freshwater Delta, CALFED, 2008. http://mercury.mlml.calstate.edu/wp-‐content/uploads/2008/10/04_task2mmhg_Winal.pdf

rice fields promotes the production of methylmercury beyond rates seen in naturally vegetated wetlands, whether seasonally or permanently flooded.[49]

A potential and unresolved issue of concern is the loading of urban and agricultural wastes into the Bypass, especially toxic concentrations of insecticides. Another potential issue is expansion of invasive aquatic plants in the perennial wetlands, without continual and costly oversight.

North East Delta

Planning for the Cosumnes/Mokelumne ROA habitat restoration has been going on for decades. Yet other than the lower Cosumnes Preserve, little has been done to restore tidal aquatic habitat in the East Delta. With federal and state grants, the Nature Conservancy has purchased much of the corridor from Walnut Grove east to the Cosumnes Preserve including most of the properties in Figure 1. Staten Island and McCormick Williamson Tract were purchased by the nature Conservancy more than a decade ago in the 1990s with CALFED funding. Invertebrates in the Cosumnes area have been found to have the highest concentrations of methylmercury in the Delta.

Aquatic habitat restoration in the area would be problematic considering the close association of the tidal channels with the Delta Cross Channel at Walnut Grove. Waters in the area are also warmer than other parts of the Delta and subject to warm summer inflows of the lower Sacramento River at the Delta Cross Channel. Restoration planning on projects such as the McCormick Williamson Tract is proceeding.[50]

Delta Meadows State Park was designed to preserve some of the original Delta habitats. The Park is now closed. The following is an excerpt from page 1 of the McCormack-Williamson Tract Restoration Planning, Design and Monitoring Program: "*The ultimate significance of these findings for the restoration is that regardless of careful design of a tidal gradient as has been done in other Delta projects, a restored upper Delta will be subjected to an unpredictable flood regime that will result in a spatially complex assemblage of geomorphic units that will defy conventional criteria for "success" in restoration. That is not inherently bad in that it is the natural condition of the system. However, the assumption of a well-ordered tidal geomorphic process as exists in other modern tidal freshwater wetlands is not appropriate for MWT (McCormick Williamson Tract). In addition, the presence of extremely high mercury concentrations in both the Delta Meadows and MWT create significant uncertainty in the biogeochemical fate of wetland restoration of MWT, though the opportunity exists for experts to study the biogeochemistry of Delta Meadows and establish how such a wetland functions in the face of existing pollution.*"[51]

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[49] http://www.waterboards.ca.gov/centralvalley/water_issues/tmdl/central_valley_projects/delta_hg/other_technical_reports/ybwa_hg_final_rpt.pdf

[50] https://watershed.ucdavis.edu/project/mccormack-williamson-tractnorth-delta-project-restoration-planning-design-and-monitoring

[51] https://watershed.ucdavis.edu/pdf/crg/MCWTFinal.pdf

East Delta

The lower San Joaquin channel in the Delta from Mossdale downstream to Prisoners Point (Figure 20) is also part of the East Delta that has been largely ignored by Delta restoration programs. The corridor is important for many fishes including salmon and steelhead from San Joaquin tributaries, as well as Delta species such as splittail. It suffers in summer from low flows, high water temperatures, low dissolved oxygen, algal blooms and heavy pollution loads, but it is an important corridor for many species in winter and spring.

The Stockton or San Joaquin Deep Water Ship Channel dominates the area. The channel converted the once sinuous channel to a straight channel for shipping by cutting through many points creating a series of dredge-spoil islands. The Port of Stockton owns most of these created "islands." The lower San Joaquin channel from Mossdale downstream to Prisoners Point (Figure

21) has been largely ignored by Delta restoration programs.

Figure 20. South East Delta – San Joaquin River between Stockton and Prisoners Point. The ship channel can be seen cutting through a series of Delta islands at the center of the photo. Mildred Island is at the lower center and eastern edge of Franks Tract and Old River are at the upper left.

Conclusion

Research over the past several decades indicates that Delta native fishes, especially Delta smelt, have very refined habitat preferences that should be the focus of any habitat restoration projects. The main habitat features of importance include salinity, turbidity, tidal flows, productivity, and water temperature. Creating habitat that meets most or all of these criteria is extremely difficult but necessary. Very few of the restoration projects undertaken to date meet these criteria.

Many implemented and proposed projects have fatal flaws (e.g., Liberty Island - lethal water temperatures) and did not consider these basic needs when designed and built (e.g., Decker Island, Kimball Island). Many project areas have actually deteriorated after purchase and little actual restoration was implemented (e.g., PG&E's Collinsville property). Other projects failed because necessary funds to restore, maintain and adaptively manage the areas were never provided (e.g., Chipps Island, Franks Tract). Consequently, many of these restoration sites evolved into havens for an astonishing assemblage of invasive plants and fishes and adversely impacted native species (e.g., Big Break, West Sherman Island, Donlon Island). A number of projects that could be considered a success have had mixed results with unintended consequences (Yolo Bypass).

The blunt fact is that the cumulative effects of all of the myriad restoration project that have been constructed in the Delta have not reversed the continued decline of native fisheries. This is because few restoration projects have been designed with the needs of fish in mind. And there is nothing in BDCP's proposed habitat restoration scheme that indicates it can or will produce habitat that meets the needs of fish. Indeed, BDCP proposes to exacerbate existing habitat problems.

As we've observed, native species evolved over many thousands of years in response to habitat. And that habitat included adequate physical (flow, residence time, variability, etc.) and chemical parameters (salinity, temperature, turbidity, chemical constituents, etc.), as well as the nutrients necessary for primary production to support renewable fisheries. The export projects have radically altered the Delta's hydrodynamics, which has resulted is a loss of critical flows, less variability, degraded water quality and reduced primary productivity. The yearly export of phytoplankton biomass is equivalent to more than 30% of net primary production. And BDCP proposes to expand the export of primary production to the north Delta. It proposes to move the critical LSZ habitat further east where smelt will more frequently encounter lethal water temperatures and entrainment in project pumps. It proposes make Sacramento salmonids run a gauntlet past massive new diversion facilities.

The Delta's altered hydrology has allowed numerous invasive non-native species to become entrenched to the detriment of native communities. We have transformed a variable freshwater estuary into something resembling an Arkansas lake. Creating more Arkansas lake habitat will simply create more Arkansas lake fish.

The best options for meeting the necessary fish habitat criteria is to increase flow and variability, mimic the natural hydrograph, protect the LSZ, improve water quality and reduce the export of primary productivity. But, those are the things BDCP cannot offer. Instead, the EIR/EIS predicts less flow and variability, a less protective LSZ, reduced water quality and increased export of primary production. That is not a recipe for improved habitat.

BDCP even ignores or marginalizes the obvious habitat improvements that could be undertaken. Migrating young salmon fry and fingerlings tend to concentrate in shoreline areas and adjacent and adjacent margin habitats along channels. Salmon smolts are frequently collected in the open channels migrating westward but are also found feeding in margin habitats. The shoreline restoration efforts on Twitchell, Decker and other west Delta sites have been successful. Yet, BDCP proposes to restore only about twenty miles of channel margin habitat over a span of thirty years.

Franks Tract is a death trap for smelt. Once drawn into Franks Tract, Delta and longfin smelt are unlikely to survive lethal temperatures, predation or entrainment at the south Delta pumps. There have been numerous proposals to place a barrier across False River or to wall off Franks Tract from surrounding channels. BDCP is silent on the issue.

In closing, we offer a bottom line. Habitat restoration cannot be successful if it doesn't meet the flow and water quality needs of native species that evolved over millennia. The history of habitat restoration in the Delta is that it hasn't met those needs, and BDCP will not meet those needs.

Attachment A: Comparison of this Review with the Habitat Assessment in BDCP HCP Appendix 5E

Appendix 5E of the BDCP HCP discusses some of the above areas and specific sites in the context of the proposed Conservation Measures. Unfortunately, the BDCP assessments, which are predicated on a conceptual programmatic level with few specific details, are seriously over optimistic of both the results of past efforts and the potential benefits of future restoration projects.

For example: page 5E-iv; "*In this appendix we evaluate the potential of restored habitat to enhance productivity of the Delta based on a simple depth relationship (Lopez et al. 2006) while cautioning that the realities highlighted by Lucas and Thompson (2012) may limit the value of restoration in regard to phytoplankton production.*"

The BDCP fails to consider the both the benefits and detriments of shallow water habitat, while focusing on water depth and phytoplankton. Shallow water provides key spawning and rearing habitat for most Delta native fish with its cover, turbidity, and food via aquatic and terrestrial insect and benthic invertebrate communities. However, shallow water can also contain lethal water temperature, harbor invasive plants and be detrimental to native fish.

CM5 Seasonally Inundated Floodplain Restoration

"*The proposed restoration of 10,000 acres of seasonally inundated floodplain habitat and the increase in flooding in the Yolo Bypass are expected to increase the amount and value of accessible rearing habitat for juvenile salmon and splittail. For salmon, the intent is to route salmon away from the interior Delta and through habitat that is favorable for growth.*" (p. 5.E-v)

The Bypass may be favorable to juvenile fish growth in winter compared to rivers, but its flows attract and strand many adult anadromous fish. Springtime warming of the water also increases water temperatures to lethal levels for smelt and salmon. Pollution from adjacent agricultural and industrial dischargers is a serious problem, as is methylation of mercury. Numerous unscreened diversions (some simple tide gates) pose a threat to fish. These problems are ignored in the assessment.

"*Floodplain restoration also is expected to increase the export of production downstream, providing increased food supplies (phytoplankton, zooplankton, insects, and small fish) for pelagic fish species such as delta smelt and longfin smelt (Kneib et al. 2008).*" (p. 5.E-v)

While Bypass floods are one of the benefits of wet years, BDCP provides no added Bypass flooding in drier years, when such benefits are in short supply and critically needed.

CM4 Tidal Natural Communities Restoration

"*Under the hypothetical restoration footprint, BDCP restoration is expected to add about 55,800 acres of subtidal and intertidal habitat for covered fish in the Delta by the end of the permit term, representing a 54% increase in these communities relative to current levels. The greatest* *increase in tidal acreage would be in the South Delta, followed by Cache Slough, Suisun Marsh, West Delta, and East Delta subregions; there is no restoration under CM4 in the North Delta or Suisun Bay subregions*." (P. 5.E-xi)

As we pointed out above, there is little value in developing subtidal and tidal habitats in the South Delta. There are huge problems associated with increasing such habitat in the Cache Slough area (e.g., warm isolated habitats, mercury methylation), especially in the areas proposed (e.g., Prospect Island and leveed lands south of Cache Slough). Suisun Marsh simply is not in play in drier years. Emphasis should be on West and Central Delta.

"Splittail are expected to benefit from the restoration of tidal marsh and floodplain habitats. Splittail exhibit a wide tolerance for conditions in the Delta. Their abundance is believed to relate more to the amount and duration of flooding of Yolo Bypass and other floodplain areas used for spawning. Splittail are expected to benefit from the expansion of food production in tidal wetlands due to the expanded flooding of Yolo Bypass (CM2) and, to a much lesser extent, other floodplain areas (CM5)." (P. 5.E-xii)

Splittail do relatively well in wet years with existing floodplains; it is in drier years when they would benefit from such actions, which are not provided in the BDCP floodplain prescriptions. Splittail may benefit from South Delta floodplain restoration, but in drier years most splittail production is lost to South Delta exports.

"The expectation is that restored shallow areas would promote production of tules and other native macrophytes that will increase the availability of aquatic insects, other invertebrates, and detritus to augment food for covered fish species. The change in the prod-acres index over the implementation period relative to the current level suggests that, by the end of the permit term (LLT), restoration benefits to food production would be greatest in Cache Slough followed by the South Delta… Transfer of this production to food for listed fish species could be complicated by potential consumption by clams, nutrient levels in the Delta and hydrodynamic factors. However, benefits can be maximized by restoration design and adaptive learning of restoration methods in the Delta." (P. 5.E-xii)

This is another example of the gross over-estimation of benefits from the proposed BDCP restorations. First, the Cache Slough area is already highly productive and shows no sign of food limitations. Second, there is little evidence that any of the productivity from the area is transferred to the Delta in drier years when benefits would be greatest. There is little chance that benefits can be "maximized" by design or adaptive learning. The three major areas proposed, leveed lands south of Cache Slough, Prospect Island, and Yolo Ranch, if converted to tidal habitats as discussed earlier, would have devastating negative effects on Cache Slough area habitats as well as habitats downstream in the Central and West Delta.

"BDCP restoration will modify flood conveyance levees and infrastructure to restore 10,000 acres of seasonally inundated floodplain along river channels in the South Delta." (P. 5.E-xii)

Again, the need for and potential benefit of South Delta floodplain restoration are greatly overestimated. Much of the benefit is estimated to accrue from the South Delta to salmon and splittail in wet years. Production of both species is already relatively good in wet years in the San Joaquin, but minimal in drier years when the proposed habitat benefits would not accrue.

CM6 Channel Margin Enhancement

"*There is some indication that channel margin could be extremely important rearing habitat in years with low precipitation when floodplains are not functioning. A study by McLain and Castillo (2009) found that densities of Chinook salmon fry in the Sacramento River and Steamboat Slough were higher compared with Miner Slough and Liberty Island Marsh during a low outflow year. Fry apparently bypassed marshy habitats at the downstream end of the Yolo Bypass because outflow during the winter was relatively low and flows into the Yolo Bypass were negligible (McLain and Castillo 2009)*." (P. 5.E-vi)

The majority of BDCP channel margin habitat restoration is located above Rio Vista on the Sacramento. The crucial channel margin habitats of the Delta migration corridors of the lower Sacramento and San Joaquin rivers are ignored. In drier years, these habitats are critically important to many Delta fishes including young salmon, steelhead, splittail, and Delta smelt. The BDCP proposal for channel margin restoration is totally inadequate given the importance of such habitat. As mentioned above, channel margin restoration has been some of the most successful restoration efforts to date in the Delta.

"By targeting areas that have been shown to have poor habitat value and biological performance coupled with extensive occurrence of covered fish species, it is possible that channel margin enhancement, together with associated restoration activities such as CM7 Riparian Natural Community Restoration, can provide more than a proportional 4% increase in overall habitat value. Such locations include the greatly altered reach of the Sacramento River between Freeport and Georgiana Slough, for example." (P. 5.E-xiv)

The 20-mile prescription for channel margin restoration in the BDCP is inadequate. The spot treatments prescribed are totally inadequate for a restoration category that has been proven successful and needed. The greatly altered large leveed channel upstream of Rio Vista would be difficult to restore and is not the area of greatest need. The many miles of channel margins between Rio Vista and Collinsville, Antioch and Pittsburg, and around Sherman Lake are more important and largely un-leveed. These areas are also adjacent to important shoal and pelagic habitats, unlike the prescribed Freeport to Georgiana Slough reach upstream of Rio Vista that will be subject to the direct effects of the BDCP tunnel intakes.

Expected Benefits to Fish from BDCP Restoration

Appendix 5E is wildly optimistic as to the potential benefits to key fish species from BDCP-prescribed restoration.

Cache Slough ROA

Delta Smelt: "*The decrease in HSI for the egg-larvae stage is the result of increased water temperatures in the subregion by the LLT primarily due to climate change impacts. There was* *almost no change in the HSI value for temperature over the period due to covered activities alone reflecting the lack of impact of the BDCP on temperature in Cache Slough*." (P. 5.E-95)

Our earlier discussion of the Cache Slough locations especially Liberty Island and Prospect Island clearly point out that these areas are too warm for Delta smelt from spring through summer, especially in dry years. The BDCP analysis of the effect on water temperature of adding 10,000 acres of open water on water temperatures is seriously flawed. The added tidal exchange alone will draw the LSZ further into Delta and expose fish to potentially lethal water temperatures. Water diversions from the area including the NBA will also have an impact. There may be little change in HSI values because the area is already too warm in spring and summer, especially in dry years.

Salmon: **"***Salmonids, those that enter the Yolo Bypass, make extensive use of the Cache Slough area. Fish can move down through the bypass and into Cache Slough where their survival is affected by local conditions. Tidal marsh restoration in Cache Slough is likely to benefit primarily juvenile foraging salmon by providing access to high-value areas for rearing. Increases in size at ocean entry have been shown to correlate with increased ocean survival (Claiborne et al. 2011). The aggregate effects of these improvements in habitat availability and environmental condition are likely to result in better outmigration success for juvenile Chinook salmon*." (P. 5.E-100)

The prescribed actions for the Yolo Bypass only affect habitat in winters of wet years and do little for salmon in dry years when such benefits are critically needed. Adding slightly to the frequency of inundation in wet years will not provide the needed benefits for salmon.

Longfin Smelt: **"***The overall impact was toward appreciably greater habitat for longfin smelt in Cache Slough although it is not clear from this analysis whether the increase in habitat quantity compensates for the decrease in habitat value (HSI) related primarily to increasing temperatures*" (from climate change).

West Delta ROA

Delta Smelt: "*The West Delta subregion currently provides HUs largely for larval and juvenile delta smelt with relatively small amount of habitat for delta smelt spawning (Table 5.E.4-24). This is because most of the subregion is subtidal with a small amount of tidal freshwater (Figure 5.E.4-67)*." (P. 5.E-105)

This statement is simply not true. The entire West Delta ROA from Collinsville to Rio Vista is generally freshwater in winter and spring of most years and has ideal shoreline habitat for spawning smelt. Such statements reflect the lack of understanding in the BDCP of the actual habitat requirements of many of the species of interest.

"*Suitability was lowest in all time periods for juvenile delta smelt because of low turbidity in summer and fall months*." (P. 5.E-106)

One reason for the lower turbidity is that the South Delta water export facilities pump water from the LSZ, which is replaced by high inflows from Sacramento River reservoir releases. Despite such effects, Longfin and Delta smelt still concentrate in the LSZ in the West Delta in all but the wetter years. The increases in habitat values predicted are small because so little habitat restoration is proposed in the West Delta. What habitat is proposed, at Dutch Slough, North Sherman, and Decker Island, as outlined in my report above have overly optimistic benefits predicted for these sites given their location, restoration design, and potential function. It should be noted that the proposed North Delta water exports would further reduce turbidity by 7 to 8 percent.

Comments on Appendix 5EB – Review of Restoration in the Delta

"*This report summarizes the lessons learned from previous restoration activities in the Delta, to provide a starting point for planning and study of restoration concepts: what should we try to replicate or avoid?"* (P. 5.E.B-1)

These conclusions, as to benefits of past restoration efforts, are overly generous and lack scrutiny on many levels.

Liberty Island

Liberty Island is a case in point: "*In some cases, accidental changes have resulted in improved conditions for native fish species (e.g., Liberty Island)"* (P. 5E.B-1).

The many problems with Liberty Island (e.g., warm water, high inorganic turbidity, high methylation of mercury, etc.) make it a poor model for future restoration.

"*For example, the apparent success of the Liberty Island transformation appears to be due in part to the juxtaposition of flow from the Sacramento River (Yolo Bypass) and Cache Slough, tidal flux and wind that result in high turbidity, movement of sediment, and local prey production. Sediment comes primarily from Yolo Bypass and the inward movement of sediment from Suisun Bay during the summer, which, along with strong summer winds, keeps the area turbid during the portions of the year that Yolo Bypass is not flooded. The result appears to be that the island provides on-site habitat and food for delta smelt and other species (Whitley and Bollens 2013) while also exporting some of its production.* " (p5E.B-5) "*This site is perhaps the best example of the potential for restoration to provide habitat and food for native fish species. Liberty Island is part of a large complex of planned restoration areas and naturally restoring areas, including Cache Slough, Little Holland, and Prospect Island, and it is also hydrologically connected to the Sacramento River and is downstream of Yolo Bypass*." (P. 5E.B-13)

The wide, open, shallow embayments of Liberty Island and Little Holland Tract are very turbid from wind fetch across the islands. However, the shallow, muddy waters are not natural and certainly not tidal marsh as they were historically before reclamation. Waves and floods are continually eroding the inorganic soils of the two areas, which were previously under intensive agriculture and are now part of the Bypass. The shallow waters warm excessively in the intense sun and warm air of late spring through early fall. Water entering the area from the Bypass Tule Canal can be best described as agricultural "return" water with high levels of organics, nutrients, agricultural chemicals, and other pollutants. Smelt are able to survive the summer only by seeking refuge in deeper nearby channels and holes scoured by historic floods. Their ability to survive the summer is highly questionable. The habitat may in fact have been better before the island breaching when narrow deep sloughs surrounded the original marshes or more recently the reclaimed agricultural islands (this would apply to both Liberty Island, Prospect Island and Little Holland Tract). Adding thousands of acres more of such habitat by breaching levees south of Cache Slough, north of Liberty Island, and on Prospect Island following the Liberty paradigm could be disastrous.

"*An important feature of the Liberty Island site it that it is hydrologically complex; these hydrodynamics shape environmental conditions and the resulting biological response. The site is at the downstream end of the Yolo Bypass and is heavily influenced by freshwater flow from the Sacramento River. It is also subject to significant tidal fluctuations that push water upstream and then pull water back downstream. The result is high turbidity and flow conditions that appear to have limited the growth of SAV*."…"*Tidal flow rather than river discharge was 43 responsible for 90% or more of the material flux into and out of Liberty Island* (P. 5E.B-14).

The site is not heavily influenced by freshwater flow from the Sacramento River except during floods. Normally its minor inflows are from the Bypass Tule Canal. Tidal flows do enter the lower end of Cache Slough near Rio Vista, but only have a minor influence on lower Bypass water quality and habitat conditions.

"*The landward transport of sediment, surrounding backwater sloughs with high residence time, and complex morphology—along with large open areas where sediment is resuspended by wind and tidal currents—are all physical drivers that allow Liberty Island to have habitat suitability that favors native species like delta smelt*." (P. 5E.B-15).

The Liberty Island habitat does not favor Delta smelt. By midsummer most smelt in the area are found in the Sacramento Deepwater Ship Channel to the east of the Bypass. Liberty Island is generally too warm for smelt by early summer.

Decker Island

"*Restoration at Decker Island, which involved restoration of a U.S. Army Corps of Engineers dredge spoils site, has been plagued by development of dense Egeria beds, especially in shallow channels that were created at the site (Rockriver 2008). Nonnative fish species were more abundant than native species in restored channels with dense vegetation. Rockriver (2008) recommended substrate changes to discourage centrarchid fish species (e.g., bass), and chemical applications to control SAV*." (P. 5E.B-6).

The site is also plagued with water hyacinth (FAV), which requires chemical treatment by the Department of Boating and Waterways. Shallow channels primarily a problem when they "dead end." Flow-through channels tend to stay open, although Egeria and other invasive SAV plants invade most Delta shallow water habitat.

Franks Tract

"*In contrast to the more complex hydrodynamics of Liberty Island, the lake is primarily influenced by tidal flow*." (p5E.B-15).

Franks Tract has very complex hydrodynamics beginning with tidal inflows from False River and Old River, along with negative flows down Old River from the Tract to the South Delta export pumps.

Mildred Island

"*Currently, the deep water at Mildred Island appears to prevent Egeria and clams while allowing phytoplankton production (Lucas et al. 2002)… Breaching of Mildred Island, on the other hand, resulted in relatively little Egeria and net production of phytoplankton to the Delta, though it also harbors large populations of nonnative predatory fish (Nobriga et al. 2005)*." (P. 5E.B-16)

Any plankton production would likely be exported at the South Delta export pumps, as net flows are almost always in that direction, which is why there are few native fish. Neither Franks nor Mildred should be left in their present state, as they offer refuge and breeding areas for nonnative fishes, as well as sinks for native fishes.

Big Break

"Big Break is presently a flooded island similar to Franks Tract. Pilot-scale restoration projects within it will: (1) restore tidal marsh, floodplain, and Antioch dune habitat on the Delta of Marsh Creek to restore target fish and dune species, (2) restore bio-filtration floodplains along urbanizing reaches of Marsh Creek to protect and improve water quality entering the Delta, (3) monitor aquatic species in Big Break and water quality along Marsh Creek, (4) develop a volunteer-driven native plant nursery to generate plants for restoration, and (5) continue a public outreach, education, and citizen planning program in the watershed to monitor the project over time." (P. 5E.B-17)

As discussed previously, the Big Break pilot projects offer little value for Delta native fishes, leaving another extremely poor habitat complex within the West Delta low salinity zone area that should be restored.

Donlan Island (P.5E.Bp-17)

The EIR/EIS fails to mention the dysfunctional nature of this restoration site. (See previous discussion of this site.)

Sherman Lake (P. 5E.Bp-18)

The EIR/EIS fails to mention the dysfunctional nature of much of this site (e.g., large areas of invasive FAV). (See previous discussion of this site.)

Prospect Island

"*Prospect Island has flooded seven times since 1981, and likely has little value for agriculture (Sanderstom et al. 2010). Therefore, the intentional breaching and re-flooding of Prospect Island could create beneficial habitat for Delta and migratory fish species (Sanderstom et al. 2010).*" (P. 5E.Bp-18)

Or it could just as easily create very poor habitat conditions as discussed previously.

Dutch Slough

"*The 1,200-acre pasture site has the potential for restoring over 6 miles of shoreline and a mosaic of tidal, riparian, and upland habitats, to provide enhanced fish and wildlife habitat in the western Delta. The unique, relatively unsubsided site topography would allow restoration of intertidal dendritic channels.*" (P. 5E.B-19)

As stated earlier, the Dutch Slough project would create poor habitat similar to Big Break and Franks Tract and its waters and aquatic production would drawn eastward toward the South Delta export pumps.

McCormack-Williamson Tract

"*The McCormack-Williamson Tract is a 1,654-acre island located immediately downstream of the confluence of the Cosumnes and Mokelumne Rivers, owned by The Nature Conservancy. The island offers opportunities for restoration of critical tidal freshwater marsh and floodplain habitat (Grosholz and Gallo 2006; Moyle et al. 2007) and may also moderate flood flows in the northern Delta, and is particularly suitable for expanding shallow water and tidal marsh habitat in the Delta.*" (P. 5E.B-20)

As discussed earlier, the island is "downstream" of the Delta Cross Channel, thus its flows are destined for the South Delta exports. The area is too warm in summer for Delta smelt. It does not lie in the spawning and rearing zone of Delta smelt.

Decker Island

"*Collectively, these efforts should lead to the long-term sustainability of a complex wetland ecosystem with considerable wildlife, water quality, and aesthetic benefits (California Department of Water Resources 2013).*" (P. 5E.B-21)

As discussed previously, the Decker Island DWR mitigation site is largely dysfunctional. There are no plans to adaptively rebuild the site to make it functional nor are there any specific plans to restore the remainder of the island that has a Corps dredge spoil easement.

What are the Major Flaws in BDCP's Proposed Native Delta Fish Habitat Restoration Program?

Given the described weaknesses in the BDCP habitat restoration prescriptions described above, what are the fundamental flaws in BDCP's approach to habitat restoration?

1. Above all, BDCP assumes that the quantity of habitat is more important than the quality of habitat. It ignores the fact that habitat restoration must replicate the quality of habitat under which species evolve over eons.
2. There is too much focus on tidal marshes that the fish will not use, which provide little indirect benefit to fishes through foodweb enhancement, and are located in areas of the Delta that are not beneficial.
3. There is a lack of focus on pelagic habitats particularly in the key Low Salinity Zone which typically occurs from lower Suisun Bay into the West Delta (most important is the Collinsville to Rio Vista reach of the lower Sacramento River and the Pittsburg to Prisoners Point reach of the lower San Joaquin River, as well as the confluence waters of the two rivers of Eastern Suisun Bay).
4. There is little emphasis on channel margin habitat particularly in the regions mentioned above in #2.
5. There is disregard for the many neglected areas that need restoration funding to fix poor habitat conditions despite decades of pleas from their government and NGO owners and managers (e.g., Sherman Lake, Big Break, Franks Tract, McCormick-Williamson Tract).
6. There is too much emphasis on areas that are too salty (Suisun Marsh), too warm (Cache Slough/Bypass and South Delta), and where waters are destined for South Delta exports (South and East Delta).
7. There is a lack of emphasis on salinity control and water temperature, and tidal flows and mixing, freshwater inputs, and Delta exports that control these key habitat features.
8. More emphasis is needed on the physical controls that are available or could be installed to enhance salinity and water temperatures of the important habitats (e.g., Montezuma Salinity Control Weir, Delta Cross Channel Gates, temporary installed weirs, Head of Old River Gates, and South Delta export facilities).
9. There is no mention of managing the open water (pelagic) habitats along the hundreds of miles of deepwater dredged shipping channels that have greatly affected the Delta, or mitigating for the ongoing effects of dredging on these habitats.
10. There is a disturbing disregard for water quality in the Delta, not just water temperature and salinity. Methylmercury is a serious problem in tidal marshes and seasonally flooded habitats emphasized by BDCP. Many of the solutions recommended (e.g., source control, etc.) for these problems are infeasible or unlikely to be successfully implemented.
11. Many important areas have simply been left out of the plan (e.g., Grizzly Bay, Montezuma Slough, Chipps Island, Collinsville, West Sherman, Big Break, Franks Tract, northern shoreline between Collinsville and Rio Vista, lower San Joaquin from Jersey Point to Prisoners Point, lower Old and Middle Rivers, lower San Joaquin downstream of Stockton to Prisoners Point, eastern Suisun Bay from Pittsburg to Antioch including New York slough and the southern shoreline).
12. There is a lack of emphasis on fixing hydrological connections such as Montezuma Slough, False River, Dutch Slough, Three Mile Slough, Delta Cross Channel, Sacramento

Deepwater Ship Channel, Georgianna Slough, Miners Slough, Sutter Slough, and Steamboat Slough to enhance the Low Salinity Zone of the Bay/Delta.

13. There is nothing in the Plan that will effectively address non-native invasive aquatic species that have undermined the native habitats and fish communities.
14. There is little in the Plan that addresses basic nutrients and the base of the food chain – phytoplankton production.

About the Authors

Tom Cannon has studied and surveyed many of these habitats over the past four decades in various roles as a fishery biologist involved in the Delta. His professional career has focused on estuarine fisheries ecology with experience on East Coast and West Coast estuaries and degrees in fisheries ecology, biology and biostatistics.

From 1977-1980, Tom was project director of Bay-Delta ecological studies for PG&E's Bay-Delta power plants effects studies that included habitat assessments of each of their Delta sites. From 1980-1982, he was a consultant to the State Water Contractors, the National Marine Fisheries Service and the State Water Resources Control Board (State Board) determining the effectiveness of the 1978 Bay-Delta water quality standards in protecting the Bay-Delta ecosystem and striped bass population. In 1986-1987, he consulted to the State Water Contractors and Bureau of Reclamation during State Board hearings on water quality standards.

From 1994-1995, he consulted to the State Water Contractors and the California Urban Water Agencies working on the 1995 Bay-Delta water quality standards and how the new standards would affect the Bay-Delta ecosystem and its fish populations. Between 1995-2003, he was a consultant to the CALFED Bay-Delta Program where he worked on various teams assessing the effects of alternative Delta operations, habitat improvements and water supply infrastructure. From 2002-2010, he was involved in activities related to the Striped Bass Stamp Program, Salmon Hatchery Program and Delta fish surveys funded by the U.S. Fish and Wildlife Service to assess the effects on Delta fish and habitats.

In the past decade, Tom worked closely with the Fishery Foundation of California, California Striped Bass Association and the California Sportfishing Protection Alliance on Delta science related to fisheries, water quality standards and the Bay Delta Conservation Plan. For Wildlands Inc. he supported efforts to develop wetland and fisheries habitat throughout the Delta region and co-authored a 2007 report on fish use of shallow water habitats of the Western Delta for Wildlands Inc. and Fishery Foundation. There he compared fish populations and habitat from surveys conducted between 2002-2007 in the Western Delta with earlier surveys conducted in 1978-1979.[52] He has personally surveyed many of the restoration sites in this report.

Bill Jennings is a life-long fisherman who has been with the California Sportfishing Protection Alliance for more than thirty years, serving as both its Chairman and Executive Director. Between 1995 and 2005, he also served as Deltakeeper, where he oversaw an extensive water quality monitoring program that was approved by the State of California and which worked closely with the Aquatic Toxicology Laboratory at U.C. Davis and state and federal agencies in collecting water samples throughout the Delta. Bill has spent thousands of days on Delta waters patrolling, monitoring and fishing and thousands of additional days participating in administrative and legal proceedings before state and federal agencies protecting water quality and fisheries. He is personally familiar with many of the restoration sites discussed in this report.

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[52] Cannon, T. and Kennedy T., Fish Use of Shallow Water Habitats of the Western Delta 1978-79 and 2002-07, May 2007.