TARGETS FOR PROTECTION OF THE DELTA ECOSYSTEM AS AN INTEGRAL PART OF A HEALTHY ESTUARY

1. Introduction

Restoration of the Delta ecosystem so that it functions as an integral part of a healthy estuary is one of two co-equal goals of the Delta Vision process (Delta Vision Recommendations 1 and 3). Achieving this goal will require:

1) establishing appropriate and measurable **ecosystem performance targets** set at levels sufficient to achieve and sustain the desired levels of ecosystem functions;

2) identifying **ecosystem management and restoration strategies** that, based on scientific understanding of the existing system and projected future conditions, will contribute towards achieving the ecosystem performance targets; and

3) establishing an **adaptive management** process for regular evaluation of progress towards the ecosystem performance targets and ecosystem response to implemented management and restoration actions.

This attachment identifies ecosystem performance targets to guide development and implementation of the Delta Vision's Strategic Plan for restoring the Delta ecosystem.

2. The Restoration Recipe, Performance Targets, and the Strategic Plan

The Delta Vision Ecosystem Work Group (EWG) has developed a simple framework to describe the relationships between desired ecosystem characteristics and the physical and biological problems and stressors that drive and/or are indicative of poor ecosystem function. We used the EWG's "restoration recipe" to identify ecosystem performance targets for the overarching restoration goal and for the broad categories of restoration of habitats and ecological processes and

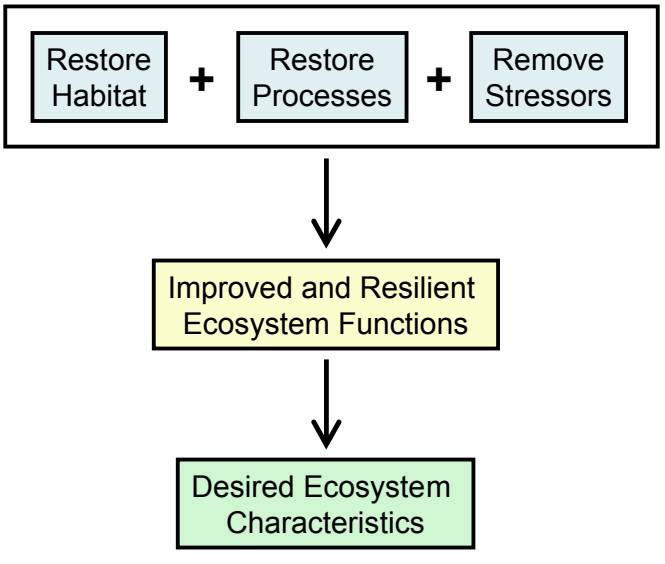

Figure A-1. The Ecosystem Work Group's "restoration recipe" guided development of ecosystem performance targets.

removal of stressors that are needed to reach the desired level of ecosystem function (Figure A-1). We then used this analysis to identify a suite of ecosystem management and restoration actions and strategies that can be implemented to achieve the performance targets and the Delta Vision goal for Delta ecosystem function.

3. Metrics, Rationale and Target Levels for the Ecosystem Targets

For the Delta to function as an integral part of a healthy estuary it must support viable and resilient populations of estuarine species, provide a migration corridor for migratory species, and support human services such as flood protection, water quality, and recreation. We have developed nine quantitative performance targets organized into four broad categories of ecosystem attributes that, when fully met, will provide the level of ecosystem function necessary to meet the Delta Vision goal. In addition, performance targets for habitats, ecological processes, and stressors have been explicitly developed to help guide development of the Delta Vision Strategic Plan for ecosystem restoration (Visions Recommendations 1, 3, 7, 9 and 11) and to be direct measures of implementation restoration and management actions that will be included in the Delta Vision Strategic Plan.

A. Viable and Resilient Populations

The Delta Vision's overarching goal that the Delta function as an integral part of a healthy estuary requires that it be able to support viable, resilient populations of estuarine species. The Delta Vision Ecosystem Work Group (EWG) has identified performance targets for multiple species groups (e.g., fishes and birds). As a simpler and more appropriate alternative, we propose a single target based on estuarine fish population abundance.

Target 1. Restore abundance of estuarine fish species to greater than 104% of average levels measured during the 1967-1991 period.

Metric: Abundance of delta smelt, longfin smelt, and splittail in the Delta and upper San Francisco Estuary is measured annually by the California Department of Fish and Game (CDFG) Fall Midwater trawl Survey. Relative abundance for each of the three species (Figure A-2) is calculated from their annual Fall Midwater Trawl Abundance Index (log_{10} transformed to stabilize the wide inter-annual variances) as:

Relative abundance (species) =

[(log FMWT Index)/(mean log FMWT Index for 1967-1991)]*100

The performance measure for the three estuarine species combined is calculated as the average of the three relative abundance values (see Figure 1).

Rationale: Each of these estuary-dependent fish species uses the Delta and San Francisco Estuary in different ways. Delta smelt are year-round residents of the Delta and upper estuary. Longfin smelt spawn in the lower Delta and spend the rest of their two-year life span distributed throughout the estuary and nearshore coastal waters. Splittail use seasonally inundated floodplains in the lower watershed for spawning and the upper estuary for the rest of their life span.

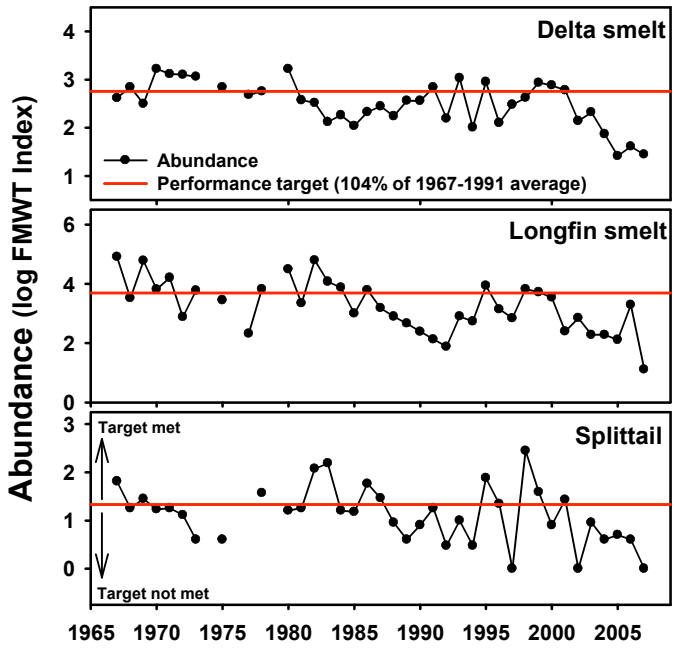

Figure A-2. Abundance of three native estuarine species relative to the 1967-1991 average abundance.

Abundance of native fish species within an ecosystem is a well-documented indicator of aquatic ecosystem health, particularly in urbanized watersheds (Wang and Lyons, 2003; Harrison and Whitfield, 2004). Native fishes are more abundant in a healthy aquatic ecosystem than in one impaired by altered flow regimes, toxic contamination and reduced nearshore habitat, the usual consequences of urbanization and water development. In addition, in the San Francisco Estuary and the Delta, the population abundances of a number of native (and non-native) estuarine fish species are strongly correlated with specific seasonal environmental conditions associated with freshwater inflow

and water quality (e.g., salinity, turbidity; Jassby et al., 1995; Kimmerer, 2002; Feyrer et al., 2007).

Protection and recovery of selected native fish species, as well as important commercial and recreational species like Chinook salmon and striped bass, has been and will continue to be the principal regulatory and policy driver for management of the San Francisco Estuary, the Delta and the Sacramento-San Joaquin watershed. Two of the native species included in the performance measure are presently listed under state and/or federal Endangered Species Acts and the third, splittail, was listed as threatened until the listing was withdrawn in 2004. Recovery of these species, as mandated by these laws, will require achieving and maintaining higher population levels than those measured in recent years.

Target level: Abundance greater than the 1967-1991 average (expressed as the average plus 1 standard error, or 104% of the 1967-1991 average) represents an abundance level at which estuarine fish populations are viable (i.e., at low risk of extinction) and resilient (i.e., capable of responding to variations in environmental conditions without collapsing. The 25 year-long target reference period, 1967-1991, includes wide variations in hydrology (e.g., very wet and very dry years as well as two multi-year droughts) and large scale climate conditions (e.g., at least two Pacific Decadal Oscillation regimes). It is also the same reference period as that established by the federal Central Valley Project

Improvement Act (CVPIA) for production goals for anadromous fishes in the watershed. During this period, the populations of the three species were resilient with their abundance levels varying predictably with environmental conditions (e.g., seasonal freshwater flows; see Fig A-5 below) and anthropogenic and biological stressors (e.g., high levels of water diversion, exotic species invasions). The abundance target was met 9 of 22 years (41%) during the 1967-1991 period and 3 of 16 years (19%) during the 1992-2007 period (see Figure 1). Abundance levels below the target measured in the 1990s and 2000s prompted listing under state and federal Endangered Species Acts for all three species, a strong indication that such population levels were not considered viable or sustainable by regulatory agencies. This target complements but does not replace existing statutory and regulatory targets for Bay-Delta species, including the federal and state requirements to double natural production of Chinook salmon and other anadromous fish species.

B. Habitats

Three of the management and restoration performance measures and targets are designed to restore the extent and diversity of physical habitat types and the complexity of channel configurations by restoring specific acreages of tidal marsh (Target 2), uplands and seasonal wetlands (Target 3), and floodplains (Target 4). While the quantitative targets are based on habitat area, four important aspects of habitat quality and function should be considered when

planning and implementing projects, and when evaluating progress towards the performance targets.

Bigger is better: Habitats that extend over large areas provide greater function, support larger numbers and greater diversity of species, and therefore have higher ecological value than small area habitats.

Connectivity is essential: Habitats that are physically connected along long interfaces to other habitat types (e.g., tidal marsh and upland habitats) provide greater function, support larger numbers and greater diversity of species, and therefore have higher ecological value that isolated habitats.

Distribute habitat broadly throughout the Delta and upper estuary: Habitats that are spatially distributed throughout the Delta and upper estuary will provide benefits to greater numbers and diversity of species than habitats concentrated in one or only a few regions (e.g., floodplain restoration in the north and south Delta will benefit both Sacramento and San Joaquin basin salmonids).

Plan for durability and resilience: Restored and/or protected habitats should be located in places that are not subject to natural (e.g., sea level rise) or anthropogenic (e.g., urbanization) loss or degradation over time.

Target 2. Restore 80,000 acres of tidal marsh habitat in the Delta and 50,000 acres of tidal marsh habitat in Suisun Marsh.

Metric: Tidal marsh area (acres) is measured as the total area of vegetated lands with elevations ranging from mean lower low water to mean higher high water that are fully exposed to tidal action and are connected to the other tidal marshes, the Delta and/or the estuary by waterways.

Rationale: Tidal marshes provide habitat for estuarine and migratory species (including some of the target estuarine fish species, as well as native plants, amphibians, reptiles, resident and migratory birds, and mammals), increase primary and secondary productivity in the estuary, export of carbon and food organisms to the Delta and estuary, and improve water quality by filtering contaminants from surface runoff and tidally exchanged waters. Nearly all historic tidal marsh habitat has been lost from the Delta and upper estuary.

Target level: The performance targets for the Delta and Suisun Marsh represent the total areas of land with the appropriate elevation in each region and are identical to those proposed by the EWG (see Figure 6 in the EWG's April 24, 2008 Draft Recommendations for Restoring the Delta's Ecosystem).

Target 3. Restore 130,000 acres of terrestrial grasslands and seasonal wetland complexes in the Delta and 5000 acres in Suisun Marsh

Metric: Upland terrestrial grasslands and seasonal wetland area (acres) is measured as the total area of lands in the Delta and Suisun Marsh with elevations above mean higher high water that support terrestrial grasslands and/or season wetland complexes.

Rationale: These habitats support wildlife, improve water quality by filtering contaminants in surface runoff, and provide accommodation space for sea level rise.

Target level: The performance targets, 130,000 acres in the Delta and 5000 acres in Suisun Marsh, represent the total areas of land with the appropriate elevation in each region and are identical to those proposed by the EWG (see Figure 6 in the EWG's April 24, 2008 Draft Recommendations for Restoring the Delta's Ecosystem).

Target 4. Restore 60,000 acres of floodplain habitat to seasonal inundation for a minimum of 45 consecutive days at least once every two years.

Metric: Floodplain habitat is measured as acres inundated by flow from adjacent rivers for 45 consecutive days during the February through May period.

Rationale: Throughout the lower watershed, historic floodplains have been isolated from their rivers by levees. Even in managed floodways like the Yolo Bypass, altered river flows and bypass weir operations prevent the floodplain from being inundated in most years (Figure A-3). Seasonally inundated floodplains provide spawning habitat for splittail (one of the target estuarine fish species), an enhanced migration corridor for juvenile salmonids, robust primary and secondary productivity for export to the Delta, and improved flood protection in adjacent and downstream areas (Sommer et al. 1997, 2001).

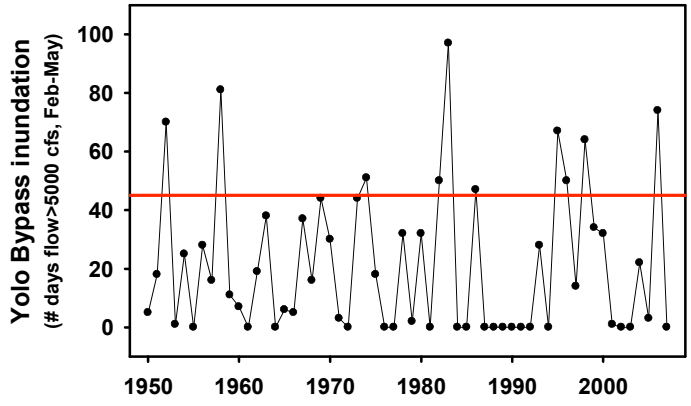

Figure A-3. The number of days during the February-May period that the Yolo Bypass was flooded (as indicated by >5000 cfs discharge from the Yolo Bypass into the Delta). The horizontal red line indicates the performance target of 45 consecutive days.

Target level: The performance target, 60,000 acres with inundation for 45 consecutive days or longer every other year during the late winter or spring, is designed to support the splittail spawning, juvenile salmon migration, and productivity objectives. The acreage target represents the total area of current functional floodplain in the Yolo Bypass and the Cosumnes Reserve but does not preclude restoration of additional floodplain area in other regions of the Delta (e.g., adjacent to the lower San Joaquin River).

C. Ecological Processes

Ecological processes in the Delta include transport of materials (e.g., by flow and tidal exchange across connections between different habitat types), primary and secondary productivity, seasonal variability in environmental conditions (e.g., flow, location and area of low salinity habitat, temperature), and disturbance (e.g., flood events). Some of these processes are provided by the natural function of specific habitat types (e.g., tidal marshes or floodplains), therefore there is some overlap between habitat and ecological processes performance targets (see Table A-4 below). In contrast to the approach used by the EWG, we have addressed the issue of estuarine open water habitat quantity and quality in terms of an ecological process with two performance targets (Targets 5 and 6) that measure that amounts of seasonal freshwater inflow and the location of the low salinity habitat (as denoted by X2, location of the 2 ppt isohaline in kilometers from the Golden Gate), rather than in terms of aerial extent of low salinity habitat

(i.e., acres). Although the area of low salinity habitat generally increases with increasing amounts of freshwater inflow (i.e., lower X2), current management of freshwater inflows to the estuary is based on a well-documented relationship between inflow volume and X2, is tightly controlled by the state and federal water projects, and strongly affects water supply reliability. However, changes in Delta geometry, including large-scale tidal marsh restoration, channel reconfiguration, or a levee failure and subsequent island flooding, as well as sea level rise in the longer term, will change this relationship. Therefore, the relationship between freshwater inflow and open water habitat characteristics, including amount, surface area to depth ratios, and water circulation patterns (e.g., water velocity, mixing v advection) should be determined to allow quantitative flow and habitat targets to be developed for future Delta configurations.

Target 5. Restore spring Delta outflow to provide low salinity habitat in Suisun Bay, with average February-June X2 values ranging from less than or equal to 70 km from the Golden Gate in critically dry years to less than or equal to 58 km in wet years.

Metric: The quantitative performance target is expressed as the average February-June X2, the location of the 2 ppt isohaline in kilometers from the Golden Gate, and varies with water year type (Table A-1).

Table A-1. Spring Delta outflow target for different water year types.

Water year type	Wet	Above normal	Below normal	Dry	Critically dry
Target (av. Feb-June X2, km)	≤58	≤61	≤64	≤67	≤70

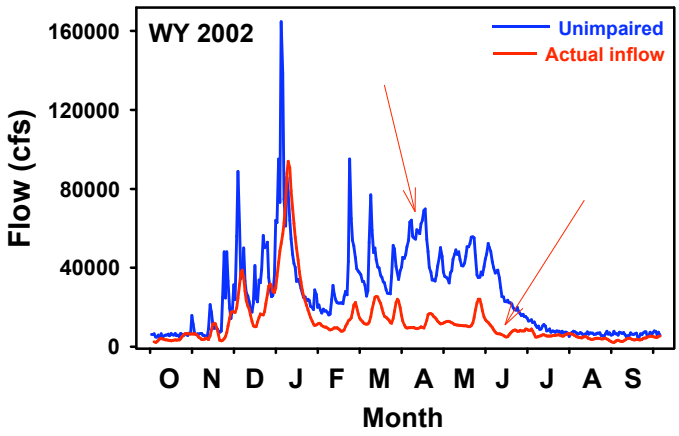

Figure A-4. Actual Delta outflow compared to estimated unimpaired runoff in the estuary's watershed. The greatest alterations in outflow from dam and Delta export operations occur during the spring (Feb-June).

Rationale: Historically, two thirds of total annual Delta outflow (i.e., freshwater inflow to San Francisco Bay) occurred during the spring, as snow in the estuary's mountain watershed melted and filled the Delta's tributary rivers. Prolonged high flows during this period are still the dominant feature of estuary's hydrograph but, as a result of upstream dams and Delta water export operations, spring is also the period of the greatest anthropogenic alterations in freshwater inflows to the estuary (Figure A-3). Spring outflows have been cut by more than 50% in half of all years since 1992 and in five of the past eight years. Many estuarine and anadromous fish and invertebrate species depend on prolonged high freshwater outflows during the spring to trigger migration and spawning, provide large areas of ecologically important low salinity habitat, and facilitate downstream transport of food organisms and young fishes. Abundance and survival of a number of estuary-dependent

species (including two of the three fish species included in Target 1) is higher when springtime X2 is located in Suisun Bay (50-60 km) and significantly lower when spring outflows are low and X2 is farther upstream. In the past 41 years, spring X2 has been upstream of 70 km (i.e., low inflow) in 40% of years.

Target level: The target levels are based on statistically significant relationships between spring X2 and estuarine fish population abundance (Figure A-5). Despite large ecological changes in the estuary (e.g., declines in food availability, establishment of invasive species such as *Corbula*), this strong relationship between spring flow and estuarine fish abundance has persisted although fish population levels are lower. The target levels for spring outflow in critical and dry years are set at levels that corresponded to minimally achieving the estuarine fish abundance target (Target 1) during the 1967-1991 period. The target levels for wetter years

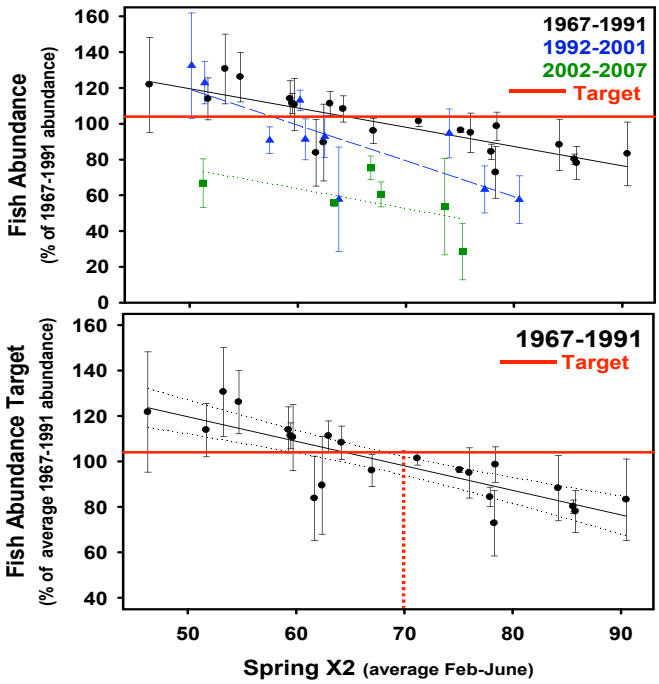

Figure A-5. The relationship between estuarine fish abundance (expressed as the percentage of the average 1967-1991 abundance; Target 1 is shown as the horizontal red line) and spring freshwater inflow (as X2). The top panel shows that, although overall abundance has declined, this statistically significant relationship is still strong despite large ecological changes in the estuary in recent years. The bottom panel shows how the relationship was used to determine the spring inflow target level necessary to achieve the fish abundance target.

that require higher spring outflows are set to ensure intra- and inter-annual variability in freshwater inflows to the estuary and to provide ecological conditions that are more favorable for native species and less favorable for invasive species that thrive in stable ecosystems with less disturbance. The spring outflow target was met five of 25 years (20%) during the 1967-1991 period and six of 16 years (38%) during the 1992-2007 period (see Figure 2).

Target 6. Restore fall Delta outflow to provide low salinity habitat downstream of the Sacramento-San Joaquin River confluence, with September-November average X2 values to less than 80 km in all years except critically dry years.

Metric: The quantitative performance target is expressed as X2, the location of the 2 ppt isohaline in kilometers from the Golden Gate, and varies with water year type (Table A-2).

Table A-2. Fall Delta outflow target for different water year types.

Water year type	Wet	Above normal	Below normal	Dry	Critically dry
Target (average Sept-Nov X2, km)	<80	<80	<80	<80	<83

Rationale: Recent research has demonstrated the decline of Delta outflow (i.e., freshwater inflow to San Francisco Bay) during the fall, the resultant decline in open water habitat quality and quantity, and the importance of providing this

habitat for delta smelt, a native estuarine resident species listed under state and federal Endangered Species Acts and one of the fish species included in Target 1 (USFWS 2006; Feyrer et al. 2007). Low freshwater outflows that result in X2 locations upstream of 80 km during the fall correspond to poor habitat conditions for maturing adult fish and lower abundances of juvenile fish measured the following spring. Recent lower fall outflows have also corresponded to the increased upstream distribution of the invasive clam *Corbula*, which prefers stable, low salinity conditions.

Target level: The target levels are based on statistically significant relationships between fall X2, open water habitat quality and quantity for delta smelt and population abundance of juvenile delta smelt measured the following spring, and are set at levels that correspond to good open water habitat quality. The fall outflow target was met 16 of 25 years (64%) during the 1967-1991 period and four of 16 years (25%) during the 1992-2007 period (see Figure 3).

D. Stressors

The Delta ecosystem is adversely affected by both anthropogenic (e.g., entrainment, pollution) and biological stressors (e.g., invasive species). Entrainment and pollution impose increased mortality rates on desirable species and their food, and sub-lethal levels of contaminants can change species' distributions, impair growth, behavior and reproduction, and cause

developmental anomalies. In addition, toxic contaminants can be transferred to people via consumption of Delta fish and waterfowl. Three performance targets address entrainment (Target 7) and contaminant stressors (Targets 8 and 9). Invasive species that alter habitat conditions and prey upon and/or compete with native species are an important stressor in the Delta ecosystem. But, while entrainment and pollution are directly responsive to management actions, there are few effective active control measures (e.g., poisons, physical removal, harvest) for eradication and/or reduction of non-native species in aquatic ecosystems that do not adversely affect native species and communities. In addition, the prevalence of non-native species in any ecosystem is a well-documented indicator of degraded habitat conditions resulting from loss of physical habitat, altered flow regimes, and impaired water quality (May and Brown 2002; Meador et al. 2003). Therefore, carefully designed management and restoration actions that address these problems can also function to reduce the prevalence and adverse impacts of invasive species. We do not recommend separate performance target(s) for this stressor.

Target 7. Limit annual entrainment losses of estuarine fish species to less than 5% of the population and to less than 2% for migratory fish species.

Metric: Currently, entrainment is monitored at only the large federal and state water export facilities in the Delta. Because abundance is measured differently

for estuarine and anadromous fish species, measures of entrainment in relation to population size will also differ. For estuarine species such as delta smelt, the most practical performance target is a ratio of the number of fish entrained to the previous year's Fall Midwater Trawl Index. For salmonids, numbers of juvenile fish can be estimated from adult escapement numbers, and the performance target would be expressed as a percentage. Initially, this performance target will be calculated using entrainment data from the federal and state water export facilities but, as additional monitoring comes on line, entrainment results from those facilities should be included in calculations of the overall entrainment rate.

Rationale: There are more than 2000 government, agricultural, urban and industrial water diversions located in the Delta and Suisun Marsh. Collectively, Delta diversions can remove more than 65% of total Delta inflow per day. Since the mid-1970s, average daily diversion rates have exceeded 50% in 12 years. Recent research suggests that entrainment mortality of estuarine and migratory fish species can be a significant contributor to population declines in some years.

Target level: The target is designed to reduce direct mortality of fishes at water diversions to levels that are proportional to their population size and are sustainable (i.e., will not cause the population to decline). The quantitative performance target for estuarine fish whose populations are measured using the Fall Midwater Trawl Survey different fish species is expressed differently,

depending on the method(s) used to estimate population size. Table A-3 shows example metrics and targets for two species and Figure A-6 shows target results for delta smelt.

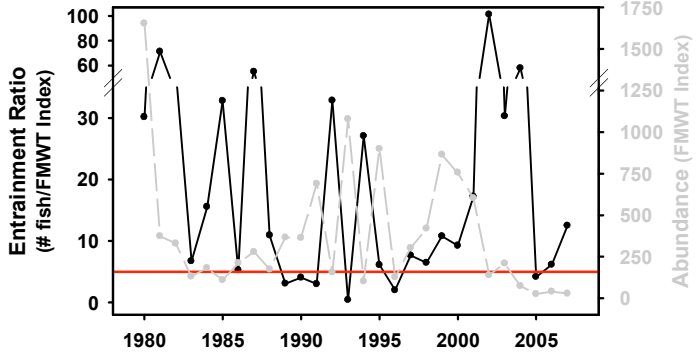

Figure A-6. The entrainment ratio (black line and symbols) and the Fall Midwater Trawl Abundance Index for adult delta smelt. The horizontal red line shows the entrainment performance target.

Table A-3. Example entrainment metrics and targets for estuarine and migratory fish species.

Species	Metric	Entrainment Target
Delta smelt	(# salvaged per year/FMWT Index)	<5.0
Chinook salmon	(#salvaged/#juvenile fish)*100	<2%

Target 8. Limit total ammonia nitrogen concentration to <0.07 mg/L and unionized ammonia concentration to <0.01 mg/l in Delta waters.

Metric: Water samples are regularly collected throughout the Delta and total ammonia nitrogen concentration (mg/L of NH_3-NH_4^+) can be measured using a variety of methods. Unionized ammonia concentration (mg/L) is usually calculated from the total ammonia concentration, pH and water temperature conditions.

Rationale: High concentrations of ammonium ion (NH_4^+), the dominant form of ammonia nitrogen in Delta and estuarine waters, can inhibit phytoplankton production (Dugdale et al. 2007) and thus reduce amounts of planktonic food available in the ecosystem. Unionized ammonia (NH_3) is toxic to fish at very low concentrations and recent research suggests that some Delta species (e.g., delta smelt) are particularly sensitive to this contaminant (Sommer 2008).

Target level: The target levels are set to minimize and/or eliminate these adverse effects.

Target 9. Reduce discharge of contaminants into Delta waterways and tributary rivers so that <5% of estuarine and anadromous fish populations exhibit evidence of toxic exposure and there are zero incidents of fish kills.

Metric: This performance target measures the prevalence of toxic contaminants in waters and sediments of the upper estuary, Delta, and tributary rivers by evaluating contaminant effects in fish species that are frequently and regularly sampled in the system. There are a number of histological and biomarker techniques that can be used to detect evidence of toxic exposure.

Rationale: Waters of the Delta and many of its tributary rivers are listed under the Clean Water Act's 303(d) list as impaired for a variety of contaminants,

including pesticides, dioxin, PCBs, metals, and mercury. These contaminants are transported into waters of the Delta and its tributary rivers via surface runoff, including agricultural and urban stormwater runoff, and direct discharges, including agricultural drains and waste water treatment plants. Recent research and monitoring has shown that Delta fishes periodically experience lethal exposure to contaminants (i.e., fish kills, reduced survival in bioassay tests) and exhibit sublethal responses (e.g., tissue and organ damage, DNA damage, reduced growth) (Sommer 2008).

Target level: The targets, no fish kills and less than 5% of fish populations exhibiting evidence of contaminant exposure, are designed to prevent incidents of direct mortality from contaminants and to reduce contaminant discharges to levels where only a small fraction of resident and migratory fish populations are exposed and/or affected.

4. Synergy Among Performance Targets

Most of the performance targets we have developed address multiple ingredients of the "restoration recipe" and will contribute towards achieving multiple desirable ecosystem functions and characteristics (Table A-4).

Table A-4. Applicability of performance targets to restoration recipe ingredients and desirable ecosystem characteristics.

Restoration Recipe Ingredients		**Performance Targets**
Restore Habitats	Tidal marsh Upland/seasonal wetlands Floodplain Open water	Target 2 Target 3 Target 4 Target 5 and 6
Restore Processes	Transport Productivity Variability	Target 2, 4, 5 and 6 Target 2, 4, 5, 8 and 9 Target 4, 5 and 6
Remove Stressors	Entrainment Contaminants Invasive species	Target 7 Target 2, 3, 8 and 9 Target 2, 3, 4, 5, 6, 8 and 9
Desirable Ecosystem Characteristics		**Performance Targets**
Viable, resilient populations	Estuarine fishes Other species	Target 1 Target 2, 3, 4 and 9
Migration corridor	Fishes	Target 2, 4, 5, 7, 8 and 9 Note: Some additional work to remove and/or mitigate physical barriers may also be required.
Human uses	Recreation Flood control Water quality Buffers	Target 1, 2, 3, 4, 5, 6, 7, 8 and 9 Target 2, 3 and 4 Target 2, 3, 8 and 9 Target 2, 3 and 4

5. Elements of a Strategic Plan for Ecosystem Restoration

Based on our analysis, the "restoration recipe" framework and the ecosystem performance targets described above, we have identified a suite of ecosystem management and restoration actions and strategies that can be implemented to achieve the performance targets and the Delta Vision goal for Delta ecosystem function (Table A-5). We have also identified how these actions will address or be affected by expected changes in the Delta (including sea level rise and changes

in timing and amounts of flow) and which performance targets and associated restoration strategies have relevance to the Delta Vision's other co-equal goal, a reliable water supply (Recommendations 1 and 7).

Table A-5. Restoration actions and strategies for meeting the ecosystem performance targets.

Target	Actions and Strategies
Estuarine fish abundance (Target 1)	1. Implement management and restoration strategies to achieve ecosystem performance Targets 2-9. Changing Delta conditions: Sea level rise and increases in water temperature may affect success and/or efficacy of some actions implemented to meet some ecosystem management and restoration performance targets. Reliable water supply: Achieving Target 1 will likely require reduced upstream and in-Delta water diversions and/or changes in diversion operations, patterns or timing.
Tidal marsh habitat (Target 2) and Upland and seasonal wetland habitat (Target 3)	1. Protect existing tidal marsh and upland/seasonal wetland habitats. 2. Restrict development on lands with inter-tidal elevations and adjacent uplands. 3. Acquire lands with inter-tidal elevations and adjacent uplands. 4. Restore tidal exchange to lands with inter-tidal elevations using appropriate project design to meet physical habitat restoration criteria and to maximize exclusion of invasive species. Changing Delta conditions: Sea level rise and existing urban development in an around the Delta may reduce the amount of available land with elevations suitable for restoration of these habitat types. Reliable water supply: No anticipated effects.
Floodplain habitat and inundation (Target 4)	1. Protect existing floodplain easements from development or other incompatible land use activities. 2. Restrict development on historic and potential floodplain lands with suitable elevations and proximity to rivers. 3. Modify weir structure and/or operations on the Yolo Bypass to allow inundation at lower flows and/or river stages to achieve frequency and duration target. 4. Acquire lands with suitable elevation and proximity to rivers for expansion of flood conveyance in the lower San Joaquin River and southern Delta. 5. Construct flood bypass and floodplain habitat in the lower San Joaquin Rivers and southern Delta using appropriate project design to meet physical habitat restoration criteria and to maximize exclusion of

	invasive species. 6. Increase reservoir releases in the Sacramento and/or San Joaquin Basins to inundate floodplains to meet frequency and duration target. Changing Delta conditions: Climate-related changes in precipitation and snowmelt patterns will likely increase the frequency and intensity of flood events in the Central Valley and the Delta. Restoration and/or more frequent inundation of floodplains may reduce flood risk to people and property. Reliable water supply: Depending on the strategy used, inundation of floodplain to meet the target could reduce water available for diversion and export.
Spring inflow (Target 5) and Fall inflow (Target 6)	1. Revise regulatory requirements to include increased seasonal freshwater inflow to the estuary. 2. Increase seasonal reservoir releases on Delta tributary rivers. 3. Decrease seasonal upstream and in-Delta water diversion rates. Changing Delta conditions: Climate-related changes in precipitation and snowmelt patterns will likely shift peak runoff to earlier in the year and may require modifications to reservoir and water diversion operations to meet new freshwater inflow targets. Intentional or unintentional changes in Delta geometry (e.g., levee breach) and sea level rise will affect the relationship between inflow and X2, requiring re-evaluation of the amounts of inflow necessary to provide sufficient quality and quantity of low salinity habitat for estuarine species. Reliable water supply: Increasing seasonal freshwater inflow to the estuary will reduce the amounts of water available for diversion and export.
Entrainment (Target 7)	1. Install fish screens. 2. Reduce water diversion amounts. 3. Change timing of water diversions. 4. Change location of water diversions. Changing Delta conditions: Sea level rise and/or levee failure on one or more Delta islands, which would cause salty water to intrude into the Delta, could a) reduce entrainment risk by reducing or eliminating current local water diversions and water export operations in the Delta, or b) increase entrainment risk by shifting distributions of estuarine fishes closer to Delta water diversions and export facilities. Reliable water supply: Reducing and/or shifting the timing of water diversions to meet the target could reduce the amounts of water available for diversion and export.
Ammonia (Target 8)	1. Reduce discharges of ammonia contaminated water. 2. Increase treatment to reduce ammonia concentrations in discharged water. Changing Delta conditions: Increases in population in Central Valley

	cities that discharge treated waste water in the Delta and tributary rivers will increase the volume of waste water discharges. Reliable water supply: No anticipated effects.
Contaminants (Target 9)	1. Implement or increase treatment of urban stormwater and agriculture runoff and discharges. 2. Increase tidal marsh, terrestrial grassland and seasonal wetland habitat area and distribution in Delta and Central Valley. 3. Require wetland and riparian buffers along river corridors. 4. Restrict discharges of untreated agricultural drainage into the Delta and tributary rivers. 5. Restrict household and/or agricultural use of problem pesticides and herbicides. Changing Delta conditions: Increases in population in Central Valley and Delta may increase household use toxic products. Reliable water supply: No anticipated effects.

6. References

Dugdale, R. C., F. P. Wilkerson, V. E. Hogue and A. Marchi. 2007. The role of ammonium and nitrate in spring bloom development in San Francisco Bay. Estuarine, Coastal and Shelf Science 73:17-29.

Feyrer, F. B, M. L. Nobriga, and T. R. Sommer. 2007. Multi-decadal trends for three declining fish species: habitat patterns and mechanisms in the San Francisco Estuary, California, USA. Canadian Journal of Fisheries and Aquatic Sciences 64:723-734.

Harrison, T. D. and A. K. Whitfield (2004). A multi-metric fish index to assess the environmental condition of estuaries. J. Fish Biology. 65:283-710.

Jassby, A. D., W. J. Kimmerer, S. G. Monismith, C. Armor, J. E. Cloern, T. M. Powell, J. R. Schubel, and T. J. Vendlinski (1995) Isohaline position as a habitat indicator for estuarine populations. Ecol. Appl. 5:272-280.

Kimmerer, W. J. (2002) Physical, biological, and management responses to variable freshwater flow into the San Francisco estuary. Estuaries 25:1275-1290.

May, J. T. and L. R. Brown (2002) Fish communities of the Sacramento River Basin: implications for conservation of native fishes in the Central Valley, California. Env. Biol. Fish. 63:373-388.

Meador, M. R., L. R. Brown, and T. Short (2003) Relations between introduced fish and environmental conditions at large geographic scales. Ecological Indicators 3:81-92.

Sommer. T. 2008. POD Update: January 2008. Powerpoint presentation made to the State Water Resources Control Board, January 22, 2008, Sacramento California. Available at: http://www.waterrights.ca.gov/baydelta/docs/pelagicorganism/012208_pod_podmt_ppt.pdf

Sommer, T., R. Baxter, and B. Herbold. 1997. Resilience of splittail in the Sacramento-
San Joaquin estuary. Trans. Am Fish. Soc. 126:961–976.

Sommer, T. R., M. L. Nobriga, W. C. Harrell, W. Batham and W. J. Kimmerer. 2001. Floodplain rearing of juvenile chinook salmon: evidence of enhanced growth and survival. Can. J. Fish. Aquat. Sci. 58(2):325–333.

U.S. Fish and Wildlife Service (USFWS) 2006. Delta Smelt Working Group Meeting notes, August 21, 2006. Available at: http://www.fws.gov/sacramento/es/documents/ds_working_group/DSWG_Minutes_21Aug06.pdf

Wang, L. and J. Lyons (2003) Fish and benthic macroinvertebrate assemblages as indicators of stream degradation in urbanizing watersheds. In *Biological Response Signatures. Indicator Patterns Using Aquatic Communities,* (ed. T. P. Simon), pp. 227-249. CRC Press: New York.