The Bay Institute

By email (deltaplancomment@deltacouncil.ca.gov)

and hardcopy

May 6, 2011

Philip Isenberg, Chair
Delta Stewardship Council
980 Ninth Street, Suite 1500
Sacramento, CA 95814

RE: DELTA PLAN THIRD DRAFT

Dear Chairman Isenberg,

This letter is submitted as the comments of the Bay Institute regarding the April 22, 2011, third staff draft Delta Plan. The draft is greatly improved from previous versions, and we generally support many of its findings and policies. However, there remain huge gaps in addressing fundamental elements of the Plan. In summary, we find that the draft:

- Does not translate the broad goals of the Delta Reform Act into specific, measurable objectives that adequately define the Council's desired outcomes for ecosystem restoration, water supply reliability, and other areas.
- Provides excellent guidance on adaptive management planning, but fails to incorporate the elements of adaptive management into the Plan itself.
- Omits any water supply policies that actually require reductions in Delta export reliance to be achieved and documented.
- Fails to describe a desired hydrograph for the Delta ecosystem, mistakenly assuming that other processes will fully address ecosystem flow needs.
- Appears very limited in its approach to levee risk reduction.
- Is unclear regarding why some elements are policies and others recommendations.

<u>What are the desired outcomes of the Delta Plan?</u>

Chapter 2 (Science and adaptive management) correctly identifies the steps necessary for

an adequate plan: a) define/redefine the problem; b) establish goals and objectives; c) model linkages between objectives and proposed action(s); and d) select action(s): research, pilot, or full-scale (p. 22). Unfortunately, the draft Plan does not follow its own guidance. The draft appears to suggest that other plans, projects and programs be subject to a consistency determination of meeting these steps while exempting itself from doing so. This is a fundamental shortcoming of the draft Plan.

The draft appears to assume that the description of desired ecosystem, water supply and other outcomes in the authorizing legislation is sufficient for purposes of the draft Plan, rather than serving as a basis for more detailed articulation by the Council. In fact, the draft Plan consistently confuses the very broad narrative goals of the Delta Reform Act (described as objectives in the legislative language, adding to the confusion) with clear, specific, measurable objectives in the sense used in Chapter 2, and defers the establishment of thresholds for success to the subsequent and derivative step of developing performance metrics (which are related, but not identical, to goals and objectives). The problem is that the Act's language is not sufficient, nor was it intended, to serve as fully articulated objectives for purposes of the Delta Plan in determining appropriate policies and regulations. In our view, the Council's role in translating the broad goals of the Delta Reform Act into a set of fully articulated objectives and constructing an integrated vision of the future Delta is one of its most important responsibilities.

The Plan should send the strongest, clearest signal possible to all those parties whose activities it will cover regarding the outcomes in the Delta that the Council hopes to secure over time. A set of overarching objectives (or targets, to avoid confusion with the legislative language) that describe the desired improvements in ecosystem conditions, water supply reliability, and other areas is the most effective way to do so, and forms the basis for developing implementation strategies, prioritizing actions, and providing other guidance to regulated parties on what covered activities will best achieve the Plan's purposes and which actions by these parties should be encouraged. There is a wealth of information available from recovery plans, regulatory decisions, public trust flow criteria, water management plans, and other sources to support the adoption of such targets. To assist the Council in this step, we have provided a draft discussion document on Delta ecosystem targets as Attachment 1.

Is the Delta Plan an adaptive management plan?

Chapter 2 contains an excellent description of the conceptual framework for an adaptive management plan. However, as someone once observed, a plan that has a chapter on adaptive management is not the same as an adaptive management plan. The draft Plan is not yet an adaptive management plan. Consistent with Chapter 2's guidance on the elements of an adequate plan, Chapters 4 through 7 should be extensively revised to better describe the problems or stressors that need to be addressed; establish specific, measurable objectives that define desired outcomes; explain the basic assumptions underlying the Plan's broad (and in our view appropriate) strategies for restoring the ecosystem, making water supplies more reliable, etc; and identify the highest priority actions for implementation to achieve Plan objectives and support Plan strategies by parties active in the Delta and covered by the Plan. Again, there is a wealth of existing information available to allow such a revision in the near future.

How does the Plan address compliance with Water Code Section 85021?

The draft Plan recognizes that the Delta Reform Act established a new state policy of reducing reliance on the Delta for future water supplies. However, none of the policies, options or recommendations in Chapter 4 actually require importing water supply agencies or importing regions to achieve and document actual or projected reductions in export reliance – let alone establish a specific target for achieving such reductions – but are limited to promoting actions that *could* reduce reliance. The Council should not assume that actions intended, or represented as intending, to reduce reliance will actually achieve real reductions, nor should it assume that real reductions will not be offset by increasing demand or capacity. WR P1 should require water suppliers and/or regions to document actual and projected net reduction in export reliance as part of their reporting obligations on total water use. In addition, WR R3 (p. 49) appears to be directly inconsistent with Section 85021, by allowing water suppliers to increase Delta diversions and demands without regard to the total Delta water budget, i.e., without ensuring that total Delta diversions and demands do not increase but rather decrease export reliance. To avoid this particular problem and better implement the new state policy, the Council should define compliance with Section 85021 as achieving net reductions. A further critical question is whether net reductions in Delta export reliance should be measured at the level of importing regions or individual importing water supply agencies. We would support measuring reductions at the regional level if adequate mechanisms for coordinating regional water management actions and documenting such reductions can be developed.

How does the Plan address creating a more natural hydrograph?

The draft acknowledges the critical ecological importance of improving the amount, timing and other attributes of flow into, through and from the Delta, but appears to defer serious consideration of a desired Delta hydrograph to the SWRCB and BDCP processes. (The disparity between the cursory discussion of more natural flow regimes and lack of new policies on pp. 64-5 and the richer discussion of improving habitat and development of new policies on pp. 65-8 is striking). Restoration of a more natural hydrograph is fundamental to achieving the Council's co-equal goal of ecosystem restoration. The draft

Plan mistakenly assumes, however, that ecosystem flow needs will solely be addressed through the State Water Resources Control Board's establishment and implementation of flow objectives and through no other mechanisms. While the SWRCB's timely action to issue new, more protective regulatory requirements for ecosystem flows is central to the Plan's success, the Plan should not limit itself to the flow objectives established pursuant to the SWRCB's authority. Rather, the Plan should describe the desired hydrograph for the Delta ecosystem, that is, include a more detailed description of the causes and magnitude of hydrologic alteration and of the basis for and magnitude of flow improvements necessary to support ecosystem restoration. The desired hydrograph may very well involve improving flows over and above those flows required by the SWRCB in its upcoming water quality and water rights rulemakings, and the Plan should promote actions by parties to improve flows over and above those regulatory requirements as necessary and appropriate, using a mix of regulatory and incentive-based mechanisms. The identification of the desired hydrograph is also important for providing guidance to other planning processes such as the Bay Delta Conservation Plan process. In developing a desired hydrograph, the Plan should defer to the SWRCB's 2010 Delta public trust flow criteria as representing the best scientific evidence regarding ecosystem flow needs (without attempting to balance these needs against other uses). There is a wealth of scientific information available to document these ecosystem flow needs and set hydrograph restoration targets (see Attachment 1 for more discussion).

WR P4 Option A should be modified to require parties to show demonstrable progress toward improving flows consistent with the SWRCB's 2010 Delta flow criteria, until such time as new flow objectives are established and implemented per WR PR 4. Furthermore, the Council should not only adopt WR P4 options B and C (p. 50), which would prevent the status quo from being degraded, but include additional actions to improve flow conditions in the interim (i.e., prior to the adoption of new flow objectives) by conditioning declarations of surplus conditions in the Delta, long-term renewal of CVP and SWP contracts, and other relevant actions not only on the adoption and implementation of new flow objectives but on demonstrable progress toward achieving flow improvements consistent with the 2010 SWRCB criteria, absent new objectives.

<u>Does the Plan adequately address risk reduction in the Delta?</u>

Chapter 7 appears to be extremely limited in both geographic and regulatory coverage and timeliness in addressing potential risks in the Delta. RR P2 and RR P3 do not cover much of the Delta, and are only intended to prevent further loss of flood capacity rather than proactively seek to expand the area of floodplain and floodway in the Delta. RR P4 defers use of levee classifications in consistency determinations until 2015 (and later for Class 5 levees). RR P6 addresses state investments in levee improvements without addressing actions by other parties to improve levees. The draft should be revised to provide a more comprehensive and complete set of policies to reduce risk from levee failure.

Why are some Plan elements policies and others not?

The draft distinguishes between policies, which function as requirements for consistency determination under the Plan, and recommendations, which do not. While it may be useful to make this distinction, it is not at all clear what the basis in this draft for designating some actions as policies and other as recommendations is. Some policies would clearly appear to be intended to bind other agencies, and many of the recommendations for actions by other agencies would appear to be essential to helping achieve the Plan's purposes. Since the Council is specifically charged with identifying those actions necessary by parties whose actions affect the Delta and successful attainment of the Plan, the reason for excluding actions as policies needs to be better explained and reviewed by the Council.

Thank you for the opportunity to provide these comments. We look forward to working with the Council toward the adoption of a truly effective Delta Plan.

Sincerely,

Gary Bobker
Program Director

ATTACHMENT 1

***** MAY 6, 2011 DRAFT *****

DEVELOPING ECOSYSTEM TARGETS FOR THE DELTA PLAN

Status of Public Trust Resources

Summary points:

- *Populations of the formerly most abundant pelagic fish species have crashed to record or near record low levels – two species are listed by the state and/or federal governments as threatened/endangered and listing petitions for other species are pending.*
- *Anadromous fish populations have also crashed, devastating the California commercial and recreational fishing economies. Steelhead, green sturgeon, and two unique populations of Chinook salmon are listed as threatened in the Bay-Delta's watershed.*

The Sacramento-San Joaquin Delta Reform Act of 2009 (Division 35, Part 1, Ch 1, § 85002) declares the Sacramento-San Joaquin Delta (Delta) to be a critically important natural resource for California and the nation, serving concurrently as both the hub of the California water system and the most valuable estuary and wetland ecosystem on the west coast of the Americas. The legislature has also declared this resource, held in trust for the people of California, to be in crisis (Division 35, Part 1, Ch 1, § 85001a). Numerous vertebrate and invertebrate species that are protected as public trust resources use the Delta and environs for spawning, rearing, as a migration corridor, or some combination of these. The Delta ecosystem itself, its habitats and natural communities, is also a public trust resource. The brief overview of the condition of public trust fisheries resources in the Delta is not meant to be a comprehensive assessment, but only to highlight current population status and trends for key pelagic and anadromous species representative of overall conditions for public trust fisheries resources in the Delta.

Overview: In general, populations of important delta fisheries have been greatly reduced from historic levels and the declines are continuing or accelerating. The most abundant pelagic fisheries have experienced dramatic declines in population abundance over the past decade, falling to record or near record lows. Anadromous fisheries that rely on the Delta are either persisting at relatively low population levels or have experienced significant declines in recent years. These patterns indicate that the Delta is at risk for, or may in fact be in the process of, ecological collapse. Such a collapse would dramatically impact the suite of public trust values in the Delta, values that have been recognized to be of state, national, and global ecological and economic significance.

Status of Pelagic fisheries: The Interagency Ecological Program (IEP), a consortium of nine state and federal resource agencies, has undertaken a decades long fish population monitoring program in the Delta and San Francisco Estuary, developing one of the longest and most comprehensive data records on estuarine fishes in the world (Sommer et al. 2007). Important results of this research include: 1) the annual abundance of pelagic fish populations in the Delta are highly variable, 2) much of this variability is associated with hydrology and anthropogenic effects of water management operations in the Delta and its Central Valley watershed, and 3) beginning around the year 2000, populations of the four most abundant pelagic fish species in the upper estuary (the native delta smelt and longfin smelt, and non-native striped bass and threadfin shad) have experienced dramatic declines (Sommer et al. 2007). These recent declines have been widely recognized as an issue of significant concern, and have come to be referred to as the Pelagic Organism Decline (POD).

The POD is notable both for affecting populations of native and non-native species, and for population abundance estimates falling to record and/or near-record lows for the most common pelagic Delta fisheries (DFG 2010a). Using the federally endangered delta smelt as an example, California Fish and Game fall midwater trawl abundance indices[1] set sequential new record lows in 2004, 2005, 2008, and 2009 (DFG 2010a). Taken together, the recent low numbers are the lowest in the period of record and represent a real and precipitous decline since the year 2000. The condition and trend in longfin smelt populations shows a similar pattern of decline, with the fall midwater trawl abundance index falling to new lows in 2007 and again in 2009. Population indices for juvenile striped bass and threadfin shad have also fallen to record or near record lows (DFG 2010a, Sommer et al. 2007). For juvenile striped bass, the ten lowest abundance index values on record have occurred since the year 1999. Catches of threadfin shad in 2008, 2009, and 2010 were the lowest on record. A total of two Sacramento splittail have been caught by the fall midwater trawl in the last four years. The precipitous population declines in these fisheries, once the most abundant pelagic fish species in the Delta and key indicators of ecosystem integrity, represent a significant threat to the Delta's public trust fishery resources.

Status of anadromous fisheries: Populations of Central Valley anadromous fishes are generally in poor and/or uncertain condition. Abundance estimates for threatened Central Valley steelhead show a pattern of overall decline with populations at a moderate to high risk of extinction (NMFS 2009a, Lindley et al. 2007). In April 2008 the Pacific Fishery Management Council adopted the most restrictive salmon fisheries in the history of the west coast of the US in response to the sudden collapse of the Sacramento River fall-run Chinook (SRFC) and other salmon populations (Lindley et al. 2009); the fishery remained closed in 2009 and was open for a pathetically short 8-day season in 2010. The SRFC was by far the largest of the remaining Central Valley salmon runs that use the Delta for migration and rearing, and its collapse is in many ways representative of conditions for a majority of Central Valley anadromous fisheries:

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[1] Available for delta smelt, longfin smelt, striped bass, and threadfin shad at: http://www.dfg.ca.gov/delta/projects.asp?ProjectID=FMWT

the long term degradation of riverine and Delta estuarine habitats resulted in a population vulnerable to collapse in the event of short-term perturbations, like a decline in ocean conditions (Lindley et al, 2009). Although the 2010 population increased in terms of raw numbers and with respect to the preceding generation (the 2007 spawning class), returns are still barely above historical lows and well below expected returns.

Other Central Valley Chinook salmon distinct populations continued a multi-year decline in 2010. Within our lifetime, winter-run Chinook populations have fallen from recorded highs of as many as 230,000 fish (1969) to near extinction (less than 200 fish in the early1990's); after a modest recovery corresponding to wet conditions at the start of this century (over 17,000 winter-run returned in 2006), their numbers declined by over 90% between 2006 and 2010. Threatened spring-run Chinook have experienced a similar long-term decline: falling from historic abundances of over 600,000 fish in the 1940's to record lows that triggered listing under federal and state endangered species acts in 1999, this species experienced a moderate rebound populations in the early 2000's but significantly again in 2009 and 2010 – escapement over the past three years is lower than when the population was listed a decade ago. These fluctuating population levels demonstrate that Central Valley salmonid fisheries are sensitive to both positive and negative environmental and anthropogenic influences on conditions in the Delta and have the potential for significant recovery under suitable conditions.

Non-salmonid anadromous fish have also experienced steep population declines Both the white and the threatened green sturgeon populations appear to have experienced declines in recent years, but data limitations make accurate population estimates difficult (DFG 2010b, NMFS 2009). Data are available on American shad abundance, with fall midwater trawl data indicating that populations are declining in a pattern similar that seen among the pelagic fisheries of the Delta: with the exception of a few good recruitment years (most notably 2003), American shad populations have seen record or near-record lows over the past decade, with four of the six lowest fall midwater trawl abundance indices being recorded between 2007 and 2010 (DFG 2010a).

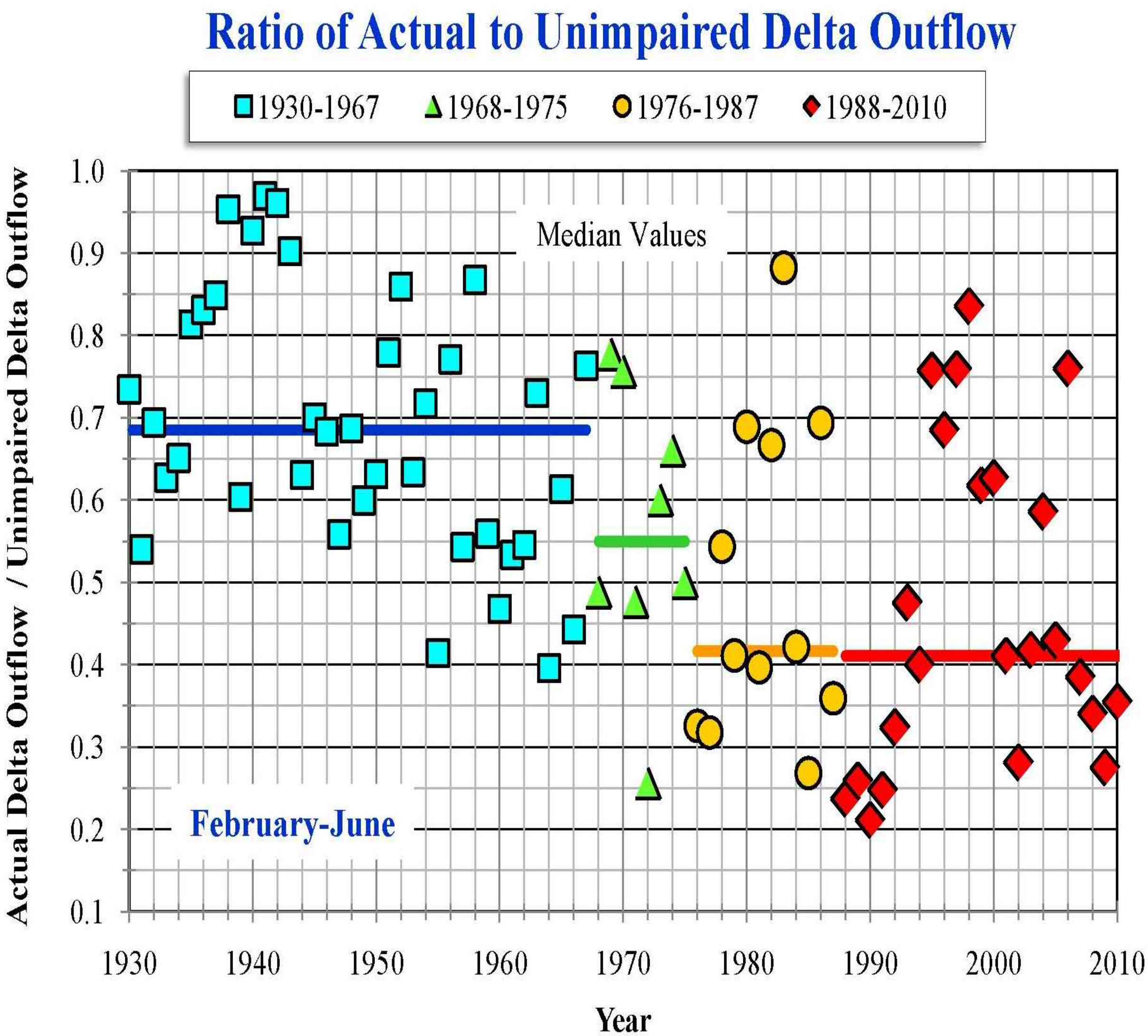
Status of Key Ecosystem Characteristics and Processes

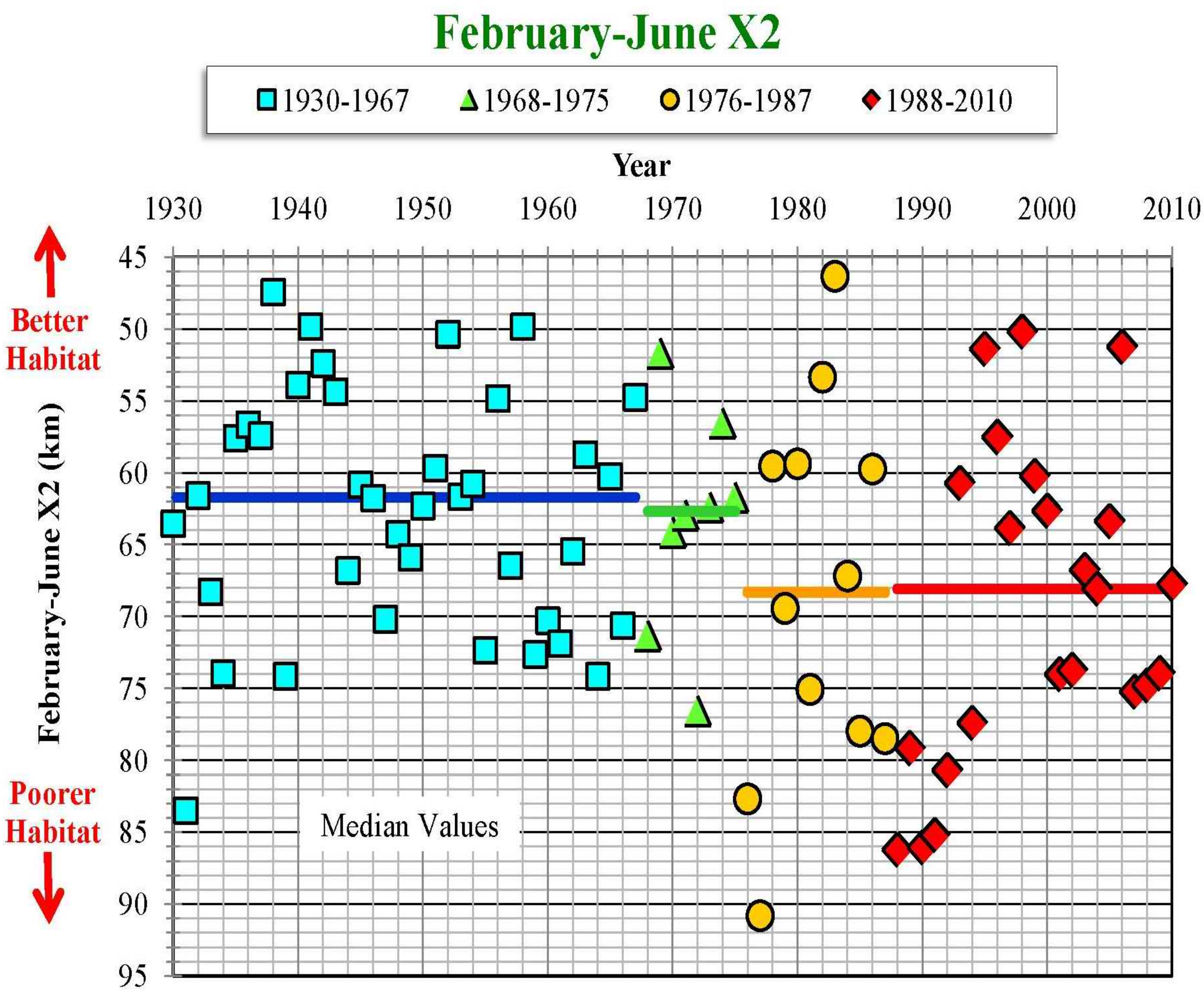
FRESHWATER FLOW: The timing, duration, sources, and magnitude of the Delta's freshwater inflows, outflows and in-Delta circulation (the Delta hydrograph) has been dramatically altered over time by water storage, diversions, flood control, and export infrastructure and operations. These alterations have had equally dramatic effects on the health of Delta public trust resources. The Delta hydrograph has been and remains the most important driver of this ecosystem's physical, chemical, and biological characteristics.

Freshwater flow conditions have worsened in recent years, despite the attention given to the Delta. Freshwater inflows from the San Joaquin basin into the Delta reached near record lows in several years during the 2000s, in-Delta diversion rates were higher than for nearly all years except those during the 1987-1992 drought, both the frequency and magnitude of reverse flows on the lower San Joaquin River were worse than for any period in the record, and Old and Middle River flows were negative more than 90% of the time. Delta outflow, one of the most critical drivers of ecological conditions in the estuary, is also a good indicator of overall flow conditions in the Delta. Figure 1 reveals the steady decline in the fraction of Central Valley precipitation in the winter and spring that makes it through the Delta as outflow; diversion of more than 60% of the available water supply (unimpaired flow) is now commonplace.

As Delta outflows have decreased, the average location of X2, the 2ppt isohaline indicator, has moved far upstream in most seasons. Through 1975, average (median of years) X2 location in the winter-spring was <63 km from the Golden Gate. Since that time, median winter-spring X2 has shifted upstream by more than 5km, with values in many years close to 75km (Figure 2). Because X2 (or log outflow) is related to the logarithm of abundance, this upstream shift in X2 corresponds to high magnitude changes in pelagic species abundance and distribution.

Figures1 and 2:


Ratio of Actual to Unimpaired Delta Outflow
1930-1967
1968-1975
1976-1987
1988-2010
Median Values
February-June
Actual Delta Outflow / Unimpaired Delta Outflow
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
1930
1940
1950
1960
1970
1980
1990
2000
2010
Year


February-June X2
1930-1967
1968-1975
1976-1987
1988-2010
Year
1930
1940
1950
1960
1970
1980
1990
2000
2010
Better Habitat
Poorer Habitat
February-June X2 (km)
45
50
55
60
65
70
75
80
85
90
95
Median Values

PHYSICAL HABITATS: The geometry and bathymetry of the Delta and its watershed have been radically altered since the mid-19th century. Alteration of the geometry of the Delta and its watershed reduced overall habitat area, decreased the maximum and average patch size of key habitats (limiting their utility), and tended to isolate habitat patches from one another, limiting the connectivity typically required for exchange of organisms, nutrients, and food among the different Delta habitats. The Delta's system of levees isolates almost all of the region's former tidal wetlands and floodplains from tidal and freshwater flows, eliminating these essential spawning and rearing habitats for native fishes and invertebrates. Only about 5% remains of the Delta's formerly expansive tidal wetlands (Williams 2006). Multiple dams on each of the Bay-Delta's major tributary rivers impair and eventually block migration of the Central Valley's anadromous species. For example, more than 85% of historical spawning habitat for Central Valley steelhead is now located behind impassable dams (Williams 2006). As described above, the flow of direction, magnitude, variability, and timing of fresh water flow have been altered by the human hydrosystem and land-use patterns that are designed to make the Delta into a north-south water conveyance system – these forces further limit the volume and distribution of fresh and brackish water that are the habitat for aquatic organisms (Kimmerer et al. 2009).

WATER QUALITY:

The recent decline in Delta productivity probably arises from the interaction of numerous stressors (USEPA 2011). In addition to flow and habitat modifications, water quality modifications (i.e. nutrients, contaminants, temperature and turbidity) are also likely to impact aquatic species, although the mechanisms and magnitudes of these impacts are less certain than the well-documented flow and habitat effects. An increase in the application of pyrethroid pesticides corresponded to detection of tissue abnormalities in at least two Delta fish species and these chemicals are known to have deleterious impacts to aquatic organisms even at extremely low concentrations (USEPA 2011). In addition, the composition and volume of chemical inputs to the Delta from irrigation return flow, levee seepage, precipitation runoff, and wastewater treatment facilities has changed over time in ways that may stress already depressed aquatic populations. Furthermore, ammonia/um discharges from the wastewater treatment plants may produce loadings that negatively affect algal community composition and growth, and new regulatory requirements have recently been imposed on the largest dischargers.

The net impact of Delta water quality on public trust resources is uncertain, but the precautionary principle suggests that reduced loading of and stronger controls for contaminants, and expanded monitoring for the presence and effects of contaminants are warranted. The effect on contaminant concentration of restored functioning habitats and more natural patterns and volumes of fresh water flow through the ecosystem should not be ignored.

Objectives for Restoration of the Public Trust Fisheries and Broader Bay-Delta Ecosystem

This section identifies proposed objectives[2] that provide more specific definition to the overarching goal of ecosystem restoration. Objectives are specific, measureable, achievable, relevant and time-bound (SMART) targets that define attainment of a particular goal. Taken together, these targets are intended to serve as the detailed articulation of the Council's vision of a restored ecosystem and allow us to develop, evaluate, select and implement restoration actions and adaptive management responses that are appropriately scaled to attain the goal efficiently. In simple terms, objectives are used to clearly define "success" and to design restoration actions that are likely to be most effective in achieving the restoration goal. Once these actions begin to be implemented, monitoring progress towards objectives tells us when our restoration activities are working or not working, how much more work there is to be done, and when we have succeeded in restoring the ecosystem.

Ecosystem restoration targets are divided into two categories: those that are species-specific and those that define habitats and processes that represent the desired restoration state. For species-specific objectives we identify a subset of fish species with a diverse set of life history requirements that cumulatively serve as a surrogate for the needs of the Delta watershed's broader native aquatic communities. Providing for the behavioral and ecological needs of these target species will require restoration of the ecosystem processes that allowed the Delta to support its native species historically. In this approach, restoration of target species serves as both a goal and a metric representing successful restoration of the ecosystem. Habitat and process restoration objectives are calibrated to the maximum extent possible to support restoration of the target species, but they also represent valid targets in their own right. Restoration of historical habitats and processes to simulate natural patterns and restore important threshold characteristics is intended to support a variety of species and ecosystem functions.

Because objectives are time-bound, we identify interim objectives that will allow us to measure progress towards implementation of the Plan (Table 1). These interim objectives also provide formal opportunities for reflection and necessary course-adjustments. If species-specific interim objectives are attained, then implementation of the next phase of restoration actions may be more flexible and targeted – certain actions may be deemed unnecessary to continue restoration progress. On the other hand, species-specific interim objectives that are not attained indicate the need to aggressively implement all restoration activities relevant to that species in order to accelerate restoration progress.

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[2] We understand that the Delta Council's Plan may use a different nomenclature than we use here; for instance, what we call "objectives", others might call "performance measures". To avoid unnecessary confusion, we look forward to modifying our terminology in future documents to match that of the Plan.

At each stage, actions will be justified by how their projected outcomes relate to specific objectives and a monitoring/research strategy that will allow evaluation of the action's success or failure. This "logic chain" architecture for describing restoration activities and expected outcomes has been fully developed in the BDCP process. The logic chain requires an explicit statement of the justification for each project with reference to one or more of the stressors that the Plan attempts to address, including attendant uncertainties, expected positive outcomes, possible negative outcomes, risks, and opportunities to learn. This detailed description (which may include areas of great uncertainty) facilitates assessment of risk, cost/benefit analysis, phasing opportunities, and design of an adaptive management program that monitors performance of key assumptions in the design. Throughout implementation of the Plan, new information will be added to our scientific knowledge base and restoration activities will be adjusted to reflect this continuous learning.

SPECIES VIABILITY CRITERIA

Protection of public trust resources requires maintaining or restoring the viability of public trust resources so that they may persist for future generations to use and enjoy. Maintenance of a sustainably harvestable fishery is inherent in the definition of the public trust for aquatic resources. As we use it here, "viability" refers to maintenance of acceptable levels or conditions of four different biological characteristics that relate to the persistence of populations and estuarine ecosystems:

- Abundance
- Spatial extent (or distribution)
- Diversity
- Productivity/Resilience

The characteristics of viability we use here are based on those defined by the National Marine Fisheries Service for "viable salmonid populations" (McElhany et al. 2000; Lindley et al 2007); they are also generally accepted throughout the conservation science literature (e.g. Meffe and Carroll 1994). Populations must achieve acceptable levels of each of these characteristics in order to be relatively safe from extirpation; analogous concepts apply to the protection of ecosystem attribute.

While there are many distinct species and ecosystem attributes that need to be protected as public trust resources, time, space, and data constraints prevent a thorough analysis of each species' requirements for this proceeding. Instead, we present recommendations for "umbrella" species that are important keystone species in their own right, whose needs are likely to exceed those of other species in the same area at the same time – by protecting an ecologically and behaviorally diverse suite of these target species, the Delta Plan will achieve overarching protection for a variety of species important to the Public Trust. In addition, we identify targets for critical ecosystem attributes that must be restored both to benefit species of concern and because they represent characteristics of a functioning Delta ecosystem as defined in Sections 85022(d) and 85302(c) and (e) of the Delta Reform Act.

In testimony to the State Water Resources Control Board, we defined for a variety of species minimum protective levels of each attribute and related these levels to specific quantities, times, sources, and durations of fresh water flows (TBI 2010a-d). The State Board's final flow recommendations reflect this approach (SWRCB 2010). Here, we use a similar approach to identify ecological objectives for the Delta Plan that will fully protect aquatic and terrestrial resources and allow the Delta to support and protect economic activities that are vital to California. A fully restored Delta ecosystem will support a thriving commercial fishery, provide flood protection for the Delta's urban areas, and provide water for local agricultural enterprises. We stress that, although the Delta and its watershed have been heavily altered by human activities and structures, the Delta Plan need not envision a future for this ecosystem that is less functional, abundant, or productive than it has been in the past. Indeed, for many species and ecosystem characteristics, it is possible that future conditions may be better than those in the historical record, which encompasses a period when resources had already been heavily impacted.

Abundance

- *More abundant populations are less vulnerable to environmental or human disturbances and risk of extinction.*

The number of organisms in a population, or an index of that behaves similar to the total number, is a common and obvious species conservation metric. For instance, endangered species recovery plans (USFWS 1995a; NMFS 2009) and plans to implement legislation mandating restoration of target species (USFWS 1995b) generally identify abundance targets against which conservation success may be measured. Populations or species with low abundance are less viable and at higher risk of extinction than large populations as they provide insulation against environmental variation, demographic stochasticity, genetic processes, and ecological interactions. Abundance is also correlated with and contributes to other viability characteristics including spatial extent, diversity, and productivity. In itself, however, simply increasing abundance of organisms (or any other single viability characteristic) is not sufficient to guarantee viability into the future.

Population abundance may be constrained by any number of biological and physical limits. For example, limitations on the area/volume of habitat with appropriate physical and chemical characteristics for any particular life stage may cap a species population. Food availability or predator densities can reduce suitable habitat space even further. Clearly, water quality improvements and creation/restoration of physical habitat may affect target species' populations either directly or indirectly (e.g. through their effect on predators and prey).

Our testimony to the SWRCB documented the powerful, significant, consistent, and widespread positive effect that fresh water flows have on viability of many fish species and their prey in the Delta and the upper reaches of its watershed (TBI 2010 a-d). The SWRCB (2010), Department of Fish and Game (2010c), and US Environmental Protection Agency (2011), among other agencies, acknowledge the critical role that fresh water flows play in supporting public trust values in the Delta ecosystem. These agencies have stated unequivocally that cumulative diversions of fresh water have been too high to support the Central Valley's Public Trust resources. Studies documenting the relationship between freshwater flow and abundance show statistically significant relationships, across orders of magnitude in abundance and flow, for numerous species (e.g., Stevens and Miller 1983; Jassby et al. 1995; Kimmerer 2002a; Rosenfield and Baxter 2007; Sommer et al. 2007; Feyrer et al. 2007; Kimmerer et al. 2009; Thomson et al. 2010). Several recent studies have noted "step-changes" (the displacement of the regression line by a constant value) in the fresh water flow-abundance relationships. Nonetheless, the correlations between fresh water flow and abundance are still strong and relevant. The statistical significance and slope (magnitude) of the flow-abundance relationships remain unchanged for many of the estuarine species studied (e.g. Kimmerer 2002a; Rosenfield and Baxter 2007: Kimmerer et al. 2009). The freshwater flow-abundance relationships are often "log:log" relationships, meaning that population responses are proportional to the order of magnitude of flow increases – these are powerful, high-magnitude effects. Two recent studies (Rosenfield and Baxter 2007 and Kimmerer et al. 2009) analyzed data from multiple sampling programs, collected over three to four decades, and found that the freshwater flow-abundance relationships were persistent, high-magnitude, and statistically significant. TBI's testimony to the SWRCB (TBI 2010b) clearly demonstrated the relationship between Delta fresh water outflow and the inter-generational change in longfin smelt and *Crangon* shrimp abundance indices since 1987.

Spatial extent (or distribution)

- *More widely distributed populations are less vulnerable to catastrophic events and risk of extinction.*

Maintaining or restoring spatial distribution of fish and wildlife species is a critical component of protecting these species and maintaining the public trust. The notion that spatial distribution is inversely proportional to extinction risk is axiomatic to modern conservation biology (e.g., MacArthur and Wilson 1967; Meffe and Carroll 1994; Laurance et al. 2002). Populations or species with limited or less varied geographic distributions are more vulnerable to catastrophic events, such as episodes of lethally elevated water temperature, disease, toxic spill (e.g. the 1991 metamsodium spill on Cantara Loop), drought, or other localized disturbances. The effect of geographic distribution on extinction risk is also apparent in the geographic attributes of endangered freshwater fish species (Rosenfield 2002). Increased spatial distribution reduces susceptibility to localized catastrophes, predator aggregations, and disease outbreaks while simultaneously increasing the probability that at least some dispersing individuals will encounter habitat patches with favorable environmental conditions. The need to maintain adequate spatial distribution is regularly acknowledged in regulatory planning and decision-making regarding the Delta and its environs (e.g. USFWS 1995b; NMFS 2009a).

A species' or population's spatial distribution is limited both by the availability of appropriate life-stage specific habitats and the connectivity between habitats appropriate for different life stages – organisms cannot occupy habitat they cannot access. Thus, the distribution of suitable habitats and the connections between those habitats must be maintained at the times of years when those habitats are used by particular life stages of target species. Restoration and maintenance of habitat and suitable migration corridors (including suitable physical, chemical, and biological attributes) are essential to the Delta's migratory fish and invertebrate species, including four runs of Chinook salmon, steelhead, Sacramento splittail, longfin smelt, Delta smelt, green and white sturgeon, starry flounder, *Crangon* shrimp, and others.

Fresh water flows into, through and out of the Delta contribute directly to maintaining the spatial distribution of both resident and migratory species. Multiple mechanisms may contribute to this relationship (some or all of which may operate on different life stages of different species). Increased flows may transport larval and juvenile fish into, through, or out of the Delta (Kimmerer 2002b). For example, Delta inflows flows from the San Joaquin River are believed to contribute significantly to the survival and eventual return of salmonids migrating from the San Joaquin basin (DFG 2005; TBI 2010c). Inadequate flows may also represent a barrier to migration; for example, fresh water flow rates are critical to preventing development of low dissolved oxygen in the lower San Joaquin River (Jassby and van Nieuwenhuyse 2005), which likely represent a barrier to fish migrations into and out of the San Joaquin basin. Thus, unless certain threshold flows into and out of the Delta are maintained, many migratory species will be unable to reproduce successfully in the San Joaquin River watershed – a severe restriction on their geographic range and major negative impact on the public trust. In addition, fresh water flows through and out of the Delta appear to increase the area of habitat available to estuarine species (e.g. Kimmerer et al. 2009; Feyrer et al. 2010) and disperses fish into that habitat (e.g. Dege and Brown 2002).

Diversity

- *Populations that maintain phenotypic and life history diversity are more resilient to environmental change and less at risk of extinction.*

Natural diversity must be protected both within populations of specific public trust species and within the ecosystem as a whole. Natural diversity (e.g. life history patterns[3]) allows populations to adapt to and benefit from environmental variability. This is an especially important characteristic in highly variable ecosystems such as the Delta. Variability among individuals in a population increases the likelihood that at least some members of the population will survive and reproduce regardless of natural variability in the environment. For example, peak flows and associated environmental conditions (e.g. turbidity and salinity) have always been temporally variable in the Delta. Delta smelt and longfin smelt display protracted spawning periods in this ecosystem (Figure 1; Bennett 2005; Rosenfield and Baxter 2007; J. Hobbs, U.C. Davis, *personal communication*, December 3, 2009) and as a result, in every year some of their larvae hatch and metamorphose into juveniles at the appropriate time to capitalize on suitable environmental conditions. Similarly, for each run of Central Valley Chinook salmon, migration through the Delta occurs over many more months than the spawning/incubation period (Moyle 2002; Williams 2006); this suggests that historical environmental variability made migration success through the Delta and its environs, or the timing of ocean entry, less predictable than the timing of spawning/incubation success upstream.

Maintenance and restoration spatially distributed high quality spawning and rearing habitats will facilitate maintenance of the historical spectrum of life histories produced within populations of target fish species. Furthermore, it is critical that the these habitats and necessary corridors between life-stage specific habitats be maintained throughout the full duration of species-specific life history and migration periods as temporal diversity in migration patterns allows the Delta's aquatic populations to capitalize on the unpredictable nature of resources in subsequent habitats (e.g. Rosenfield 2010; Miller et al. 2010). Thus, actions that maintain habitats and corridors that are well distributed in time and space are preferable to those that would tend to concentrate impacts in particular locations or consistently at certain times of year.

Water management activities in the Delta and its watershed may adversely impact early or late entrants into a given life stage in a way that may truncate the population's typical duration of that life stage. For example, as currently implemented, freshwater flows designed to protect emigrating San Joaquin salmon (VAMP flows) may select against early or late-migrants to the Delta. Similarly, Delta smelt entrainment at the south Delta water export facilities may select against the large early-spawning Delta smelt that are believed to be more fecund than later spawning Delta smelt. The Delta Plan should provide for natural patterns of variability in ecosystem attributes and seek to eliminate disproportionate impacts that limit the typical duration of a life stage for target species'.

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[3] Although only genetically based traits are subject to evolution and not all diversity is genetically-based, it is a trait itself (genetically based or not) that confers the ability to survive and reproduce in different environments. Thus, in a conservation sense, flow criteria that protect natural diversity are protective of the public trust values whether or not the diversity is genetically based.

Productivity/Resilience

- *A population's potential for population growth allows it to be resilient to variable conditions in a dynamic estuary.*

The abundance, distribution and diversity of public trust resources cannot be adequately protected if human activities result in environmental conditions that regularly or chronically result in negative population growth (i.e., population decline), reduce the ability of depressed populations to recover, and/or cause the abundance, spatial extent, or diversity to fluctuate wildly.[4] Species or populations with persistent negative population growth, as well as populations with limited ability to respond positively to favorable environmental conditions, are less viable and at higher risk of extinction. In general, extraordinary population variability increases the risk of extirpation (May 1971) and should be avoided (e.g., Thomas 1990). Actions that impede a small population's natural ability to capitalize on the return of beneficial environmental conditions (e.g. loss of unoccupied habitat, decreased reproductive potential, mortality inversely proportional to population size) represent significant challenges to that population's viability as they impede recovery in other viability parameters.

The Delta Plan should promote actions that reduce anthropogenically driven impacts to population productivity and resilience. Of particular concern are water project operations that increase the mortality of some species when environmental conditions (low Delta inflows and outflows) and population levels are already unfavorable. For example, spawning locations for some estuarine species in the Delta appear to vary from year-to-year and are closely tied to the position of low salinity habitats (Baxter 1999; Dege and Brown 2004; Rosenfield 2010). As a result, entrainment of certain species increases during dry years (Grimaldo et al 2009; Rosenfield 2010) when these species are already stressed by poor habitat conditions.

Interim Objectives and Staged Implementation

Uncertainty and Adaptive Management

- *Adaptive management requires clear goals, quantitative objectives, and appropriate indicators.*
- *Restoration targets should be based on the best available information, informed by conceptual models and hypothesis formulation, on what ecosystem manipulations are most likely to meet the goals and objectives for both species and ecosystem processes.*
- *Performance monitoring and assessment should be used over time to evaluate success and revise restoration plans to more effectively meet goals and objectives.*

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[4] The estuarine environment is highly variable in nature (indeed, variability in some variables may define certain ecosystem processes) and we do not wish to suggest that this natural/historical variability should be constrained. However, human activities that contribute to unnaturally high variability or suppress the ability of populations to recover from periods of low abundance, distribution, or diversity endanger public trust resources.

The challenges of managing a highly complex, variable and dynamic estuarine ecosystem like the Delta are made far more difficult by the unprecedented degree of land conversion and hydrologic alteration that has transformed the Delta's landscape and hydroscape over the last 150 years. Emerging threats such as climate change and seismic risk increase the uncertainties exponentially.

Managing adaptively in such a challenging environment requires, first and foremost, the adoption of clear goals that define the Delta Plan's purposes; specific, measureable, achievable, relevant, and time-bound (SMART) objectives that describe the specific outcomes associated with achieving the goals; and ecological indicators that allow measurement of progress toward meeting the objectives. The recent National Research Council review of the Bay Delta Conservation Plan (NRC 2011) was emphatic on this point. The CALFED Ecosystem Restoration Program Plan, the CVPIA Anadromous Fish Restoration Plan, and the 2010 SWRCB Delta Flow Recommendations represent important foundational efforts for establishing goals and objectives for public trust resources.

Restoration criteria should be based on knowledge concerning causal mechanisms, significant correlations, and recent and pre-European historical conditions. Conceptual models such as those developed by the CDFG Delta Regional Ecosystem Restoration Implementation Plan (DRERIP) process can be extremely useful in clarifying the relationship between desired outcomes for public trust resources and proposed management actions, assessing the level of certainty associated with these relationships, and to help clarify hypotheses concerning the response of the Bay-delta ecosystem to proposed restoration actions.

Adaptive management cannot succeed without an active feedback mechanism between the managed environment and the decision-making process. This requires implementation of a well-designed, fully resourced program to monitor the response of target species and ecosystem characteristics to restoration actions and to evaluate the effectiveness these actions, in conjunction with non-management factors, in achieving goals and objectives. Such a program must be a standardized process utilizing independent review and oversight whose results are reviewed on a regular basis by the Council, in order to ensure a credible and transparent decision-making process and timely assessment of progress toward public trust protection goals and objectives.

Prioritization Principles

Several factors should be evaluated when considering which restoration actions to incorporate into the Delta Plan and which of those actions to implement in the face of adaptive management decisions. These factors are particularly important as the BDCP attempts to prioritize actions so as to achieve the maximum impact in the shortest possible time. Below, we identify and describe prioritization principles and indicate what pieces of information can be brought to bear in evaluating each restoration element in the Delta Plan with regard to these principles. These principles may facilitate initial construction and evaluation of the Plan and adaptive management choices that occur once implementation has begun and the results of early efforts become available. Note: the order of presentation does not imply a hierarchy among these principles.

Magnitude of Impact – All else being equal, actions with potential for high magnitude positive effects are preferable to those with less potential for positive impacts. Note that magnitude can refer to either tangible benefits to covered species/ ecosystem properties or to the value of information that affects our understanding of (1) target species, (2) the ecosystem, (3) hypothetical stressors that affect them, or (4) the efficacy of conservation approaches. Scientific review (such as that developed by the DRERIP process) may provide qualitative or quantitative projections regarding the outcomes of different measures; such review will also help document the assumptions underlying the projection. Every effort should be made to make quantitative outcome projections because such projections (1) allows evaluation of the action and its place in the overall conservation strategy and (2) reveals the assumptions and conceptual models underlying elements of the Plan.

Breadth of Impact – Conservation actions that benefit multiple species or ecosystem processes are of higher priority than those that serve only one species.

Certainty of Impact – Actions that are highly likely to produce their intended positive impacts are of higher priority than those for which the projected outcomes are uncertain. The DRERIP review process clearly identifies the level of scientific certainty associated with each potential outcome of any conservation action. This principle does not imply that actions with high uncertainty are never to be implemented; only that Plan elements with a great deal of documented support are more likely to produce the conservation and water supply benefits that drive Delta Plan development.

Consequences of Unintended Outcomes or Erroneous Hypothetical Basis for Action -- Because of the complex nature of ecological systems, actions taken under the Delta Plan are expected to have multiple outcomes – some positive, some negative. Measures that may cause irreparable or significant negative outcomes are less desirable than those where the magnitude of potential negative outcomes is relatively low. As with anticipated positive outcomes, potential negative outcomes must be identified in advance, along with a description of their potential magnitude and certainty. This transparency allows (1) realistic assessment of the overall value of an action and the plan as a whole and (2) design of metrics and analytical practices that will allow for the detection of such outcomes if they occur.

Reversibility – Restoration actions that are reversible (in the physical, economic, and political sense) are preferred to those that are irreversible or difficult to reverse. This stems from the above discussion of certainty and potential negative outcomes (anticipated and unanticipated). If actions are judged to be counterproductive (either biologically or because they cost too much for their associated benefits), it will be desirable to undo them.

Time Required to Demonstrate Outcomes – The Delta Stewardship Council is well aware that the conservation status of covered species and need for water supply reliability demand rapid attention. Therefore, actions that have the potential to produce positive outcomes rapidly are desirable. Management objectives, such as those identified here, are time-bounded; only those projects that can produce relevant outcomes within the time-bounds of a given interim objective can be counted as contributing to that objective. Certain restoration actions may have multiple outcomes that develop at different rates.

The time required to demonstrate outcomes is the sum of the following periods:

1) Time to implement project
2) Time for a particular expected outcome to develop
3) Time required to gather and analyze enough data to demonstrate the outcome (even preliminarily)

The implication of these three time periods is that conservation actions that will produce immediate results should be implemented immediately. Activities whose benefits will not materialize in full for some time should be connected to the attainment of late-stage objectives rather than those that are required the immediate future.

Species-specific Objectives

Anadromous species

Background – Anadromous species native to the Central Valley include four unique runs of Chinook salmon, steelhead, and green and white sturgeon. Each of these populations has experienced dramatic declines over the long and short-term; winter and spring-run Chinook salmon are listed as endangered species as are the steelhead and green sturgeon populations. Striped bass, which were introduced into the ecosystem in the late-1800s, are also anadromous and were historically far more abundant than they are currently. In the past, each of these species supported a vibrant fishery. Below, we identify specific, measureable, achievable, relevant, and time bound objectives for salmonid restoration in the Central Valley; meeting these objectives will require restoration of ecosystem processes and characteristics that will benefit all of the anadromous species in this ecosystem.

Salmonids are obviously a major component of the Public Trust and a central component of the Bay Delta ecosystem. Their anadromous life history, which carries them to the farthest accessible reaches of the Central Valley's rivers to far-flung reaches of the Pacific, exposes them to conditions throughout the Bay-Delta and its watershed. Protection and restoration of Central Valley salmonids will indicate progress towards ecosystem restoration throughout the Central Valley. Protection and restoration of Central Valley salmonids will likely provide overarching protection for other critical anadromous species in the Bay-Delta ecosystem. Although salmon have different ecological requirements from other anadromous species (striped bass, sturgeon, etc.), in many cases (but not all), environmental conditions that are protective of salmonids satisfy the needs of other anadromous species as well. Because each life stage of Chinook salmon and steelhead is present nearly-year round and because their range covers the entire watershed below the impassable dams, salmonid requirements for habitat and flow overlap geographically and temporally with those of other anadromous species. In addition, salmon are well studied and their abundance and distribution in the Central Valley is more completely documented than that of most other species. As a result, targets for salmonid restoration can be established using excellent long-term records and a relatively comprehensive understanding of species' and run-specific needs.

The CVPIA, Friant/San Joaquin River Settlement, NMFS' 2008 Biological Opinion and 2009 Draft Restoration Plan, and several review papers (McEwan 2001; Williams 2006; Yoshiyama et al. 1998) provide the legal and biological bases for setting specific, measureable, achievable, and relevant objectives for salmonid restoration.

Abundance -- Proposed salmonid abundance objectives are described in Table 2. These numbers are for naturally produced fish; hatchery production is not included. Thus, these abundance targets are not directly analogous to escapement numbers typically reported by state and federal fisheries agencies. Natural production is exactly the metric that the Delta Plan should be concerned with (i.e. the degree to which a restored Delta and watershed can, and is legally mandated to, serve the Public Trust).

Currently, only the fall run of Chinook salmon may be considered viable in the Central Valley based on abundance criteria and that population has experienced a catastrophic decline over the past decade. Actions consistent with abundance criteria for salmonids in the Central Valley are those that tend to increase the watershed's carrying capacity for one or more of the unique salmon populations in this basin. Carrying capacity may be increased by increasing the quality and quantity of limiting habitats (particularly spawning and juvenile rearing habitats).

Title 34 of the CVPIA requires that "*...natural production of anadromous fish in Central Valley rivers and streams be sustainable, on a long-term basis, at levels not less than twice the average levels attained during the period of 1967-1991...*" (Section 3406[b][1]). For each salmon run, abundance targets for adult fish were developed and apportioned across watersheds. Our recommendation for abundance targets track those from Title 34, though they have been modified to reflect: a) the presumably mistaken identification of a winter-run Chinook salmon spawning population in the Calaveras River (Williams 2006) and b) the lack of abundance targets for the soon-to-be-restored San Joaquin River system. Abundance targets were not developed under the CVPIA for a San Joaquin River spring run of Chinook salmon because no such run existed at the time. This is a good example of a point we wish to emphasize: *though the Delta and its watershed have been greatly modified, a restored system may support more fish and wildlife and/or more viable populations than we have now or than we have seen in the recent past.*

Spatial Distribution -- Salmonid populations that require the protection of the Endangered Species Act cannot be considered "restored". Geographic range size reductions threaten each of the Central Valley's salmonid populations; their geographic distribution may be increased by establishing new habitat necessary to complete a life stage and/or increasing access to that habitat. The greater the geographic separation or ecological independence of newly created and existing habitats of the same type (e.g. spawning habitats), the greater the benefit to the geographic distribution attribute of viability.

Increasing the spatial distribution of salmonid populations in the Central Valley is critical to the survival of these unique runs. Specifically, Sacramento winter-run Chinook salmon spawn in only a fraction of their historic range – a river stretch so small that it could be easily eliminated by a single chance event. Similarly, most of the remaining spring-run Chinook salmon spawning population is found in three streams on the slopes of the seismically and volcanically active Cascade Range (one of these streams hosts a genetically unique sub-population of spring-run and is thus even more susceptible to eradication). The Sacramento River basin produces all of the Central Valley's winter-run Chinook salmon, almost all of its spring-run Chinook salmon, and the vast majority of its steelhead; thus, Central Valley salmonid production is already extremely sensitive to hydrological conditions in the Sacramento River watershed. Climate change models suggest that, in the future, the southern Sierra will retain its winter snow-pack (and associated cold-water conditions) longer into the season than will the lower peaks of the Sacramento River's drainage basin. Therefore, strategic replication and enhancement of salmonid populations in the San Joaquin Basin is essential to maintaining these species in the future.

As per the NMFS' Draft Recovery Plan for Central Valley salmonids (NMFS 2009a) we recommend restoration and maintenance of:

- Three spatially distinct viable populations of winter-run Chinook salmon spawning in the Sacramento River Basin

- A minimum of six spatially distinct viable populations of spring-run Chinook salmon, two in each of the following regions: Southern Cascades ("basalt and porous lava" region), Northern Sierra, and the Southern Sierra. In addition, the plan calls for observed spawning (as opposed to "viable" populations) of spring run in the watersheds of the Northwestern Sacramento Basin.

- A minimum of eight spatially distinct viable populations of steelhead, two populations within each of four major geographic and geologic regions of the Central Valley (Southern Cascades, Northwestern Sacramento River drainage, Northern Sierra Nevada, and Southern Sierra Nevada).

Productivity/Resilience -- To achieve abundance targets, salmonid populations in the Central Valley will need to increase from present levels for several generations. Even after populations reach recovery targets, natural fluctuations in environmental conditions will cause these populations to decline from time to time. A population's productivity (for salmonids, this will be measured as the Cohort Return Ratio -- CRR) is a key factor affecting its ability to sustain recovery targets and rebound from periods with poor environmental conditions. A population's growth rate is defined by the balance between birth (fecundity) and death (mortality) rates; actions that promote population productivity will decrease mortality rates and/or increase average fecundity rates. In particular, those actions that improve vital rates in response to population declines promote viability by increasing productivity. Sources of mortality that are insensitive to population decline or those that increase proportionately when populations decline (e.g. entrainment at water export facilities) diminish a population's natural productivity.

The Delta Plan should set expectations for the frequency of population growth when abundance indices fall below targeted levels. Clearly, humans do not control all factors that affect anadromous fish populations; climatic conditions and those in the marine environment play an important role. These unmanaged (or unmanageable) drivers can be incorporated into measures of population productivity/resilience. With reference to unmanaged drivers (e.g. unimpaired hydrology, upwelling conditions), populations that increase more than expected or decrease less than expected are more productive and thus more resilient to environmental disturbances. For example, DFG (2005, 2010) describes a statistical relationship between San Joaquin River inflows and San Joaquin River Chinook salmon escapement 2.5 years later. The success of the Delta Plan should not be judged based on uncontrollable hydrological conditions (e.g. a "failure" during drought periods or a great "success" during wet periods); rather performance should be evaluated on the population growth relative to those conditions that are not or cannot be controlled. Flows in the San Joaquin are highly managed, but they are ultimately related to the unimpaired hydrology in that system. Thus, a relationship can be developed for unimpaired hydrology and subsequent salmon escapement[5] so that productivity can be measured with respect to the *potential* San Joaquin inflow. Establishing the baseline in this way actually makes success easier to attain as conditions can be improved either by increasing actual flows as a proportion of unimpaired flows *or* by improving other habitat attributes (e.g. water quality, food abundance, etc.) *or* both.

[5] This is not the same as requiring salmon returns that would be expected if actual flows equaled unimpaired flows. The relationship simply portrays what salmon returns were under given hydrological conditions (wet years, dry years, etc.) in the past.

Table 1 identifies targets for the frequency with which CRR should exceed expectations derived from historical relationships of productivity and unmanaged environmental driver. When populations attain interim abundance targets, population growth (productivity) may be constrained by density-dependent factors – therefore the CRR targets are applied only in years when abundance is less than the relevant interim abundance objective.

Diversity – To maintain the complete range of life history and phenotypic diversity that Central Valley salmonids require to overcome natural variation in the ecosystem, the Delta Plan should eliminate disproportionate impacts to a particular segments of each salmonid life stage's typical seasonal duration (i.e. spawning, incubation, migration, rearing, etc); these life stage-specific seasonal durations will differ for each of the four Chinook salmon runs and Central Valley steelhead. Descriptions of variability in life-stage durations and other life history characteristics are available in numerous descriptions of the target salmonids (e.g. TBI 2010a-d; Williams 2006; Moyle 2002).

The Plan should also describe known variants in behavior and physiology (e.g. fry migration vs. yearling migration among spring run Chinook salmon) so that actions consistent with the Plan will protect (or impact equally) the entire range of life history and phenotypes for each species/ run. Finally, the Plan should describe a target age-structure (or range of age-structures) for each of the runs based on historical patterns and encourage actions that would tend to restore these age-structures (e.g. by reducing anthropogenic selection for or against a particular life-history strategy). Documentation of historic age distributions within Central Valley salmonid populations is available in several compendia (e.g. William 2006; Quinn 2005; McEwan 2001).

Species	Attribute	Interim Objective 1 Evaluation Date: __ Number of Generations: __	Interim Objective 2 Evaluation Date: __ Number of Generations: __	Total Objective Evaluation Date: __ Number of Generations: __
Chinook salmon (winter run)	Median abundance[1]			108,000/yr
	Spatially Distinct Populations			Establish 3 spatially distinct spawning populations (total = 4 spatially distinct spawning populations)
	Productivity /Resilience	Statistical relationships between Cohort Replacement Rate (CRR) and unmanaged environmental variables (e.g. unimpaired flows[2], 3-year average water-type; ocean conditions) to be developed for the period after installation of the Shasta TCD. "Progress towards interim objectives" will be define such that, for years when abundance < target abundance: 1) CRR> historical CRR-to-unmanaged variable relationship in 6 of 8 most recent years 2) CRR> lower 66% confidence interval of historical CRR-to-unmanaged variable in all years.		
	Diversity			Distribute operational impacts equally across historical life-stage duration (see Figure __). Establish spawning age-structure ~that documented for __ by __.
Chinook salmon (spring run)	Median abundance[1]			78,000/yr
	Spatially Distinct Populations			6 (two in each of three regions) + spawning in NW Sacramento drainage.
	Productivity /Resilience	Statistical relationships between Cohort Replacement Rate (CRR) and unmanaged environmental variables (e.g. unimpaired flows[2], 3-year average water-type; ocean conditions) to be developed for the period after installation of the Shasta TCD. "Progress towards interim objectives" will be define such that, for years when abundance < target abundance: 1) CRR> historical CRR-to-unmanaged variable relationship in 6 of 8 most recent years 2) CRR> lower 66% confidence interval of historical CRR-to-unmanaged variable in all years.		
	Diversity			Distribute operational impacts equally across historical life-stage duration (see Figure __). Establish spawning age-structure ~that documented for __ by __.
Chinook salmon (fall run)	Median abundance[1]			750,000/yr
	Spatially Distinct Populations	maintain status quo		
	Productivity /Resilience	Statistical relationships between Cohort Replacement Rate (CRR) and unmanaged environmental variables (e.g. unimpaired flows[2], 3-year average water-type; ocean conditions) to be developed for the period after installation of the Shasta TCD. "Progress towards interim objectives" will be define such that, for years when abundance < target abundance: 1) CRR> historical CRR-to-unmanaged variable relationship in 6 of 8 most recent years 2) CRR> lower 66% confidence interval of historical CRR-to-unmanaged variable in all years.		
	Diversity			Distribute operational impacts equally across historical life-stage duration (see Figure __). Establish spawning age-structure ~that documented for __ by __.
Chinook salmon (late-fall run)	Median abundance[1]			68,000/yr
	Spatially Distinct Populations	maintain status quo		
	Productivity /Resilience	Statistical relationships between Cohort Replacement Rate (CRR) and unmanaged environmental variables (e.g. unimpaired flows[2], 3-year average water-type; ocean conditions) to be developed for the period after installation of the Shasta TCD. "Progress towards interim objectives" will be define such that, for years when abundance < target abundance: 1) CRR> historical CRR-to-unmanaged variable relationship in 6 of 8 most recent years 2) CRR> lower 66% confidence interval of historical CRR-to-unmanaged variable in all years.		
	Diversity			Distribute operational impacts equally across historical life-stage duration (see Figure __). Establish spawning age-structure ~that documented for __ by __.
steelhead	Median abundance[1]			40,000/yr
	Spatially Distinct Populations			8 (two in each of four regions)
	Productivity /Resilience	When abundance<50% of relevant interim objective, CRR>1 in at least 75% of years Until Total Objective attained, CRR>1 in at least 67% of years After Total Objective attained, CRR>1 in at least 50% of years		
	Diversity			Distribute operational impacts equally across life-stage historical duration

TABLE 1: Proposed Delta Plan recovery objectives for anadromous fish. Interim objectives are seperated by 10 years in order to allow for at least three generations of Chinook salmon and steelhead to experience improvements that occur under the Plan. Abundance targets are modified from, but consistent with, those required by the CVPIA; steelhead abundance target based on McEwan 2001.

[1] Refers to production (this includes fish lost to the commercial and sport fishery). Median over a 3-yr period.

[2] Statistical relationships are often developed using actual flow numbers; however, actual flow numbers result from management. Performance against a relationship to unimpaired flow allows identification of improved water management under a given hydrological background.

[3] Because abundance and CRR of steelhead have not been accurately measured in the past, productivity/resilience for steelhead cannot be measured against historical relationships between CRR and environmental variables

Pelagic species

Background – Pelagic species occupy open water habitats in the Bay-Delta. The Delta is essential habitat for at least one life stage of numerous species that either remain in the estuary throughout their life cycle or display brief migrations into coastal marine environments. These species are critical indicators of the Delta ecosystem's health and are important components of the Bay-delta food web. In addition, many pelagic species historically supported important fisheries, either directly or as critical prey items for economically important fish species (Moyle 2002). For a number of reasons, environmental protections designed to benefit truly anadromous species may not provide adequate protection to these estuarine-obligate species.

Among the Bay-delta's native fish fauna, four relatively well-studied species (delta smelt, longfin smelt, Sacramento splittail, and starry flounder) use the freshwater and low salinity habitats of the Delta in diverse ways such that restoration actions designed to protect these species are likely to benefit a suite of other estuarine species and ecosystem processes. Thriving populations of these four species indicate that the Delta's estuarine ecosystem is functioning to support the Public Trust and the public interest. In the attached appendix, we provide brief descriptions of these four "indicator" species, their different habitat use patterns, and their roles in both the estuarine food web and in human fisheries.

Abundance – In a restored Delta ecosystem, abundances of pelagic species will exceed those that were observed after operations of the State Water Project began in 1967. Specifically, our recommended objective for each of the four target pelagic species is that their respective fall mid-water trawl abundance indices exceed the *median* of the 1967-1987 indices in two-thirds (67%) of years. Given that the Delta Plan will likely identify habitat and water quality targets that will improve on conditions available during the 1967-1987 period and incorporate recommendations for improved fresh water outflow from the Delta (SWRCB 2010; CDFG 2010), this objective is quite attainable.

California Department of Fish and Game's Fall-midwater trawl aquatic community sampling program (FMWT) began in 1967, providing some of the most valuable information on historic abundances of each of these species. The Delta's current geometry was basically in place by this time – most of the former shallow water habitats were already isolated by a massive system of levees, shipping channels were well-established, and the State and Federal water projects were largely built-out by this time. In many ways, water quality during the late 1960's, prior to passage and implementation of the Clean Water Act, was not as good as it is now. Despite all of these impacts (and the known and likely declines in fish populations that occurred prior to initiation of the FMWT), the Bay-Delta system still supported sizeable populations of many pelagic species into the mid-1980s. Thus, we can use historical FMWT abundance indices to create a baseline for restoration of the Bay-Delta's pelagic species. The 1967-1987 timeframe was chosen to represent this baseline because it encompasses a period of substantial background environmental variation prior to the fish population declines that necessitated listing of some pelagic species under the state and federal endangered species acts.

Distribution –Under the goal of establishing an acceptable geographic range for spawning of the estuarine indicator species, the Delta Plan should set specific objectives for the detection of spawning in areas where pelagic fish were known to spawn in the past. Various methods, from traditional larval fish surveys to new microchemical analyses of fish bones, can be used to determine the natal location of fish (e.g. Weber et al. 2002; Hobbs et al. 2005). Specific recommendations for the spawning spatial distribution of the estuarine indicator species are found in Table 2. Again, by restoring habitats that were already eliminated by 1967 and improving fresh water flow and quality conditions, the Delta Plan should have little problem attaining these distribution targets.

Two of the four estuarine indicator species (Delta smelt and Sacramento splittail) are endemic to the San Francisco Bay-Delta. As such, their total geographic range puts these species in a class of freshwater fish species that may experience higher rates of extinction due to chance demographic and environmental events (e.g., Rosenfield 2002). It is imperative that the geographic range of these species not be further constrained. Similarly, despite the fact that longfin smelt populations exist elsewhere in the world, it is highly likely that the San Francisco Bay-Delta population is a distinct entity (one that does not usually interbreed with other populations) and is thus susceptible to the same risks as endemic species with constrained ranges. No distribution objectives are described for starry flounder, as we know of no evidence that their geographic range within the Bay-Delta has been constricted. Also, as a widespread marine species that relies on the San Francisco Bay-Delta mainly as a rearing ground, extirpation due to constriction of their geographic range within the Bay-delta is unlikely.

Historically, Delta smelt, longfin smelt, and Sacramento splittail spawned throughout the Delta, as hydrological conditions allowed (Moyle 2002). Mature Sacramento splittail migrated up the major rivers of the Central Valley to lowland floodplains. The loss of spawning habitat for each of these species is most acute in the eastern Delta, southern Delta, and lower San Joaquin River. While improvements to and expansion of spawning habitats elsewhere (e.g. for Sacramento splittail, on the Yolo bypass) are necessary to support the abundance of these species, creation and maintenance of quality spawning habitats in the eastern and southern Delta and lower San Joaquin River are essential to restore the geographic range of these species and reduce the potential for a localized catastrophe to extinguish the entire population.

Productivity/resilience –In addition to simple abundance targets, the Delta Plan should establish targets for the productivity of pelagic species. To restore the Bay-Delta ecosystem, the Delta Plan will need to facilitate actions and operations that promote population growth among target species. It is important to define acceptable progress towards population recovery because:
(1) recovering populations should grow more frequently than they decline;
(2) abundance indices vary substantially from year to year, so reacting solely on the basis of annual abundance indices is inefficient and unrealistic (our abundance targets integrate results over multiple years covering at least 2 generations);

(3) many of the target species respond to changes in environmental conditions in well-documented ways; thus, progress should be measured with respect to unmanaged, ambient environmental conditions (e.g., unimpaired flows, ocean conditions, etc.);
(4) the relatively short timeline for complete implementation of the Plan requires rapid feedback and information on progress towards abundance goals– if populations are not growing in the period between interim abundance objectives, action can be taken to get back on course.

The Delta Plan should set expectations for the frequency of population growth of populations that have abundance indices below targeted levels. Humans control many, but not all factors that impact pelagic fish populations. These unmanaged (or unmanageable) drivers should be incorporated into measures of population productivity/resilience. With reference to unmanaged drivers (e.g. unimpaired hydrology), populations that increase more than expected or decrease less than expected are more productive and thus more resilient to environmental disturbances. For example, many pelagic species have well-documented, long term, high magnitude statistically significant relationships between abundance and fresh water outflow from the Delta (e.g., Jassby et al. 1995; Kimmerer 2002; Kimmerer et al. 2009; Rosenfield and Baxter 2007; Sommer et al 2007). Testimony to the State Water Resources Control Board (TBI 2010b) demonstrated that these flow-to-abundance relationships remain in effect and that the likelihood of population growth increased markedly when flows exceeded certain threshold levels. A similarly robust relationship can be developed for unimpaired hydrology and subsequent population abundance[6] so that productivity can be measured with respect to the *potential* Delta outflow. Establishing the baseline in this way creates additional pathways to successful restoration because conditions can be improved either by increasing the proportion of unimpaired flows that become actual Delta outflow *or* by improving other habitat attributes (e.g. water quality, food abundance, etc.) *or* both. Table 2 identifies targets for the frequency with which population abundance should exceed expectations derived from recent historical relationships of productivity and unmanaged environmental drivers. For some species (i.e. longfin smelt, starry flounder), the intercept of the flow-to-abundance relationship (but not its slope) has changed over time. For these species, the relevant baseline changes over time such that there will be progress towards restoring historic levels of productivity as different conservation measures are implemented and take full effect. When populations attain interim abundance targets, population growth (productivity) may be seriously constrained by density-dependent factors – therefore productivity should be assessed only for those years when abundance is less than the relevant interim abundance objective.

We identify target population growth frequencies for pelagic species in Table 2.

Diversity -- Life history descriptions for target species' are available in numerous scientific studies, management plans for the Bay-delta and supporting documents (e.g. Rosenfield 2010;

[6] This is not the same as requiring salmon returns that would be expected if actual flows equaled unimpaired flows. The relationship simply portrays what salmon returns were under given hydrological conditions (wet years, dry years, etc.) in the past.

TBI 2010a-d; DFG 2010; Williams 2006; Moyle 2002). The Delta Plan should favor actions that promote maintenance of the full range of variation in life-stage timing and discourage actions and operations that tend to impact a particular segment of the natural temporal distribution of native species life cycles.

In highly variable and unpredictable environments such as the San Francisco Bay-Delta, life history variability and underlying genetic variability are critical to population persistence (Rosenfield 2010; Miller et al. 2010). Just as populations that are spatially constrained are susceptible to catastrophic events in space, populations with life history strategies that are constrained in time are vulnerable to ephemeral poor conditions. Actions that facilitate expression of the full range of a species' life history and genetic diversity promote population viability. Said differently, actions that tend to select against one segment of a population (those that spawn or migrate early or late, grow quickly or grow slowly, etc) erode population diversity and resilience.

Species	Attribute	**Interim Objective 1** **Evaluation Date: __** **Number of Generations:**	**Interim Objective 2** **Evaluation Date: __** **Number of Generations:**	**Interim Objective 3** **Evaluation Date: __** **Number of Generations:**	**Interim Objective 4** **Evaluation Date: __** **Number of Generations:**
longfin smelt	Abundance				FMWT Index ≥ 6,338 in at least 67% of years **or** Bay Study Otter Trawl[1] CPUE ≥ 21.1 in at least 67% of years
	Spatial Extent				Detection of sexually mature or post-spawning adults every year at a minimum of two sampling stations in both the lower Sacramento and SJ Rivers **and** As a three year running average, detection of sexually mature or post-spawning adults at a minimum of one (i.e. ≥1/yr) sampling station in both the eastern Delta and Suisun Marsh
	Productivity /Resilience				Statistical relationships between abundance and unmanaged environmental variables have been developed (e.g. unimpaired flows[2]) and abundance relationships with other variables (e.g. ammonium) may be developed for pre-clam (1967-1987), post-clam (1988-2000), and POD (2000-2010) periods. "Progress towards interim objectives" will be define such that, for years when abundance < interim target abundance: 1) in >6 of the past 8 years, abundance >(abundance):(flow) **relationship for the pre-clam years** 2) in all years, abundance > lower 66% confidence interval of abundance exceeds abundance-to-flow **relationship for the pre-clam years**
	Diversity				Distribute operational impacts equally across life-stage historical duration
delta smelt	Abundance				FMWT Index ≥ 444, in at least 67% of years
	Spatial Extent				Detection of larvae at __ sites of the 20mm survey **and** Detection of mature or post-spawning adults at __ sites of the Kodiak trawl survey including __ sites in the southern and eastern Delta
	Productivity /Resilience	No statistical relationships between abundance and unmanaged environmental variables have been developed for Delta smelt (e.g. unimpaired flows2). In lieu of scaling productivity to environmental conditions, objectives are expressed in terms of the frequency of population growth. When abundance<50% of relevant interim objective, intergeneration population growth in at least 75% of years When abundance ≥50% and <100% of relevant interim objective, intergeneration population growth in at least 67% of years After Total Objective attained, intergeneration population growth in at least 50% of years			
	Diversity				Distribute operational impacts equally across life-stage historical duration *(e.g., eliminate disproportionate take of large, early spawning females)*
Sacramento splittail	Abundance				FMWT Index ≥ 36, in at least 67% of years **and** Suisun Marsh YOY CPUE ≥ 1.92, in at least 67% of years
	Spatial Extent				Over the course of three years, evidence of spawning (post-spawning adults or rearing juvenile fish) in at least two separate spawning areas in the Sacramento River drainage (e.g. Yolo bypass and another location) **and** spawning in at least two of the following three regions: San Joaquin basin, East side rivers, Suisun Marsh
	Productivity /Resilience	Statistical relationships between abundance and unmanaged environmental variables have been developed (e.g. unimpaired flows[2]) and abundance relationships with other variables (e.g. ammonium) may be developed (these relationships do not appear to have changed for splittail). "Progress towards interim objectives" will be define such that, for years when abundance < interim target abundance: 1) in >6 of the past 8 years, abundance exceeds abundance-to-flow relationship 2) in all years, abundance > lower 66% confidence interval of abundance >abundance-to-flow			
	Diversity				Distribute operational impacts equally across life-stage historical duration *(e.g., eliminate disproportionate take of large, early spawning females)*
starry flounder	Abundance				Bay Study Index[1] ≥ 583, in at least 67% of years
	Spatial Extent				
	Productivity /Resilience				Statistical relationships between abundance and unmanaged environmental variables have been developed (e.g. unimpaired flows[2]) and abundance relationships with other variables (e.g. ammonium) may be developed for pre-clam (1967-1987) and post-clam (1988-2008) periods. "Progress towards interim objectives" will be define such that, for years when abundance < interim target abundance: 1) in >6 of the past 8 years, abundance exceeds abundance-to-flow **relationship for the pre-clam years** 2) in all years, abundance > lower 66% confidence interval of abundance >abundance-to-flow **relationship for the pre-clam years**
	Diversity				

TABLE 2: Proposed Delta Plan recovery objectives for target pelagic fish species. Interim objectives are seperated by __ years in order to allow for at least __ generations of each species to experience effects of Plan implementation. Abundance targets based on historical medians through 1987 -- these numbers reflect performance in a system that was already highly degraded; by restoring habitats, water quality, and fresh water flows, the Delta Plan can exceed these empirical baseline values in most years.

[1] original 35 sampling stations

[2] Statistical relationships are often developed using actual flow numbers; however, actual flow numbers result from management. Performance against a relationship to unimpaired flow allows identification of improved water management under a given hydrological background.

Key Attributes of Ecosystem Function

In order to restore Public Trust resources in the Bay-Delta, the Delta Plan will need to envision and create an ecosystem with ecological patterns and processes that support species of interest and tend to inhibit invasive species. In addition, the ecosystem itself is a Public Trust value that must be restored and enhanced in ways that maximize its ability to support the public trust and the public interest.

Unlike species viability criteria, an idea commonly used in such contexts as the federal Endangered Species and National Forest Management Acts, the ecosystem viability concept remains less well known, occasionally appearing in the ecosystem management literature (Brussard et al. 1998; Vogt et al. 1997). Ecosystem viability nevertheless represents a useful framework for considering the landscape-scale implications of habitat and hydrologic management and restoration – the implications of which are not necessarily adequately included in the species-by-species approach to viability analysis. Thus, although current planning efforts in the Bay-Delta tend to focus solely on species-specific viability analysis measures, we would urge the Delta Council to specifically also consider the desired ecosystem attributes in future permitting of water and land management activities within the Bay-Delta. For physical habitat restoration, this means the Delta plan would adopt a vision of the mosaic of habitat types, their connectivity, patch size, and distribution across the Delta. Regarding a more natural hydrograph, the Delta Plan would specify desired aspects of the Delta hydrograph including flow amounts and seasonal patterns at target locations within the Delta. These well-established concepts of landscape ecology (Forman 1995) and hydrology appropriately form the basis for ecosystem viability analysis, as a necessary complement to (not a substitute for) population viability analysis.

While the Delta Council will need to develop regionally specific indicators of desired ecosystem conditions related to particular target ecosystem attributes, the framework described by Brussard and colleagues (1998) provides a useful starting point, listing the four overarching criteria that need to be met for "impacted ecosystems" (such as the Bay-Delta) to be considered viable:

(1) current utility (does the ecosystem provide services expected from it?)
(2) future potential (do present uses not disrupt the processes that generate and maintain the desired ecosystem structure and function?)
(3) containment (do current conditions not degrade areas beyond the ecosystem/region?), and
(4) resilience (does the ecosystem maintain the capacity for self-maintenance and regeneration?).

A regionally-developed set of indicators for assessing the status of key ecosystem attributes would thus allow a new approach to permitting decisions regarding water management and habitat restoration activities, one that would should consider not just site-specific impacts but the interaction of Bay-Delta hydrodynamics and habitats at the landscape level.

<u>Natural Hydrograph</u>

The relationship between abundance and fresh water flow is one of the strongest and most persistent relationships observed in the San Francisco Estuary. As a result, persistent, large-scale hydrologic alterations can reduce the capacity for growth among key species and functional groups (e.g. phytoplankton, zooplankton taxa). All relevant fish and wildlife management agencies agree that improved fresh water flow conditions in the Delta and its watershed are necessary, but not sufficient, to maintain and restore the Public Trust values of these ecosystems (SWRCB 2010; US DOI 2010; CDFG 2010; USEPA 2011). In Table 3, we present key attributes of the Delta hydrograph and recommended targets that will restore and maintain the broad ecosystem services provided by freshwater flows. The best science currently available indicates that these attributes of freshwater flow will be required to support species-specific objectives described above and to promote the processes and characteristics that define the minimum desirable level of ecosystem function. As flow and non-flow restoration activities are implemented, we may learn that ecological objectives can be attained with less frequent high-volume flows; our proposal for staged implementation of flow and non-flow solutions allows for adjustments in flow criteria as interim ecosystem objectives are met.

The SWRCB (2010), CDFG (2010), and USDOI (2010) findings and recommendations regarding fresh water flows in the Central Valley acknowledge that at least six attributes of freshwater flow must be addressed to achieve maximum ecosystem benefits: the volume, location, timing, frequency, variability, and source of flows can all contribute to or subtract from the ecosystem benefits produced by flowing fresh water.

Volume – Among other things, the volume of fresh water flowing in a waterway affects its ability to:

- maintain temperatures and dissolved oxygen;
- dilute and flush toxins;
- transport nutrients, food items, and migrating fish; and
- inundate habitat.

The volume of fresh water flowing in the Central Valley also determines the interaction between fresh and salt water – in many ways, this interaction *is* the habitat for estuarine organisms and certain life stages of anadromous fishes. The volume of flow at any one time also influences the ability to export a fraction of the water for human uses.

Location -- In general, species are affected by flows in their immediate proximity (i.e., riverine species/life stages may be more strongly affected by Delta inflows or Delta hydrodynamics whereas estuarine pelagic species/life stages may be more strongly impacted by Delta outflows). Flow recommendations for specific locations in the Delta can be tied to specific ecosystem functions; but we urge the Stewardship Council to adopt regulations that maintain the *continuum* of flow in rivers and the estuary as this is necessary to insure adequate transport/retention dynamics of larval and juvenile fish, nutrients, and food items as well as upstream passage for migratory adult fish.

Timing -- Because species move seasonally and different life stages occur in different locations, the magnitude and location of their flow requirements change *seasonally*.

Frequency – Fresh water flow volumes that are necessary at certain locations during particular seasons to sustain fish and wildlife populations and support important ecosystem processes must occur often enough to sustain key ecological objectives.

Variability – related to the frequency of particular flows is the inter- and intra-annual variation between flow levels. Most native organisms in the Bay-delta system succeeded when natural patterns of high variation in flow prevailed. Maintaining the high intra- and inter-annual variability characteristic of fresh water flows in this estuary helps preserve the genetic and life history diversity of public trust resources. The Central Valley's water management system tends to reduce inter- and intra-annual flow variability and this tends to benefit non-native species disproportionately.

Source -- Failure to address the proportional contribution of each tributary to Delta inflows and outflows will undermine viability needs of the same public trust resources that require Delta flows to complete their migratory life cycles. A disproportionate allocation of releases to meet downstream criteria among source streams disrupts the connectivity required by early life history stages of migratory species that occur upstream, and contributes to adverse flow and temperature conditions in the upper watersheds.

Applying the best available science, the SWRCB (2010) fresh water flow recommendations identified the volume of flows at specific locations in the Delta that are necessary to protect Public Trust resources. The SWRCB implicitly addressed timing, frequency, and variability of flows by framing their Delta inflow and outflow recommendations as a desired percentage of the 14-day average of unimpaired flows; we strongly support the SWRCB's findings regarding the approximate volume of flows necessary to protect the Delta ecosystem and we support tethering these flow requirements to a continuous measure of recent hydrology (e.g. unimpaired flows) as they did.

The SWRCB acknowledged the importance of meeting Delta flow requirements with water from each of the watershed's major rivers (i.e. the Sacramento River, San Joaquin River, and their tributaries); however, the Board did not make specific recommendations for river flows other than for the Sacramento and San Joaquin where they enter the Delta. In order to fully protect Public Trust resources of the Delta, each of the major watersheds of the Central Valley must contribute fish, wildlife, and water resources in proportion to its capacity. The Delta Plan should identify a mechanism and pathway to achieve a proportionate contribution to Delta flows from each of the ten largest Central Valley rivers.

The flow recommendations developed by the SWRCB in 2010 were presented as the minimum required to protect Public Trust values in the Bay-Delta assuming no other actions were taken to restore the Delta. In addition to persistent declines in fresh water flow volumes and dysfunctional changes in the timing of flows into and through the Delta, there have been significant physical and biotic changes in the San Francisco Estuary ecosystem over the past half-century (e.g. Nichols et al. 1990; Kimmerer 2004; Feyrer et al. 2007). Some of those changes have likely contributed to declines in the viability of target species beyond the impact of changes in fresh water flow patterns. We believe that many non-flow-related restoration actions are available and that aggressive implementation of certain measures, particularly those with a high magnitude positive impact and high likelihood of success, could reduce the amount of fresh water flow required to support the Public Trust. Non-flow restoration actions should be implemented wherever they are justified by sufficient evidence and an acceptable risk: reward relationship. Restoration measures for which evidence is lacking should also be investigated provided they can be implemented in a way that generates scientific information to improve our understanding of stressors in the Bay-Delta and will not inadvertently cause irreparable damage to the ecosystem (i.e. they should be implemented in a manner that is reversible and small scale).

Natural Habitat Mosaic –

Physical habitats are the interaction of fresh water flow attributes with the Delta's physical geometry. The Council should explicitly consider the landscape level values of wetland and other habitats when permitting activities, and develop criteria for protection and restoration of key ecosystem attributes that are then used in the permitting process.

Wetlands –Although heavily degraded and greatly reduced in extent (USEPA 2011) the Bay-Delta's wetlands nevertheless continue to provide important ecosystem services, in several categories.

First, wetlands regulate movement of water within watersheds as well as in the regional and global hydrological cycle (Mitsch and Gosselink 1993; Richardson 1994). By storing precipitation (and infiltrating surface runoff) and then releasing it into other surface waters and groundwater, wetlands control water flow, and regulate discharge from watersheds. In addition, wetlands retard high river flows and mitigate flood damage, and protect the soil from erosion. They also play a critical role in connecting groundwater with surface waters, helping maintain water table levels and influencing hydraulic pressure, thus both recharging the aquifer and regulating its discharge to other waterbodies.

Second, wetlands are critical to biogeochemical cycling, retention, and export of nutrients and organic matter. Uniquely in wetlands, water-level fluctuations optimize coupled geochemical reactions (oxidation and reduction; Johnston 1991) that serve to transform nutrients, organic compounds and metals into biologically useful forms, or remove them from the aquatic ecosystem (e.g., heavy metals: through adsorption, and burial (e.g., in peat); ammonia: through nitrification-denitrification and atmospheric release; etc.).

Third, wetlands act both as carbon sinks, and as energy sources for the resident and migrant biota. Organic matter decomposition, coupled with slow water movement, allows the carbon to be deposited and stored within peat and wetlands soils. On the other hand, the inputs of terrestrial carbon into the detrital food chain, as well as the high rates of primary production in the wetlands, provide a large amount of biomass which represents an important source of carbon for the aquatic organisms, allowing exchange of nutrients, facilitating passage of aquatic organisms among systems (the "flood pulse hypothesis" by Junk et al. 1989), and providing a critical life support function required for spawning, migration, maintenance of species richness both in the wetland and in aquatic ecosystems up- and downstream. Thus, floodplain wetlands provide higher biotic diversity (Junk et al. 1989) and increased production of fish (Bayley 1991; Halyk and Balon 1983) and macroinvertebrates (Gladden and Smock 1990).

Finally, wetlands provide an irreplaceable habitat for plants, invertebrates, resident and migrating fish (including the endangered species of salmonids), birds, and mammals. Some of these are restricted to wetlands for their entire lives while others require wetlands for migration, rearing, or feeding (Mitsch and Gosselink 1993); endangered species are found in both of these categories (e.g., saltmarsh harvest mouse, winter-run Chinook salmon). The effect of wetlands on biological productivity, especially fish production, is well known: for example, riverine fish with access to wetlands have been shown to grow faster and/or larger than those restricted to the river channel (Junk et al. 1989; Bayley 1995). An analogous outcome has been demonstrated in the Bay-Delta (Sommer et al. 2001), showing increased survival and growth rates for juvenile Chinook salmon in the Yolo Bypass (seasonal wetland) than in the Sacramento River.

The degree to which these critical ecosystem services are provided is determined by the quantity and quality of total wetland habitat, not by the status of a single wetland considered in isolation from the larger ecological landscape. For this reason, the Delta Council should consider the importance of Bay-Delta wetlands at the regional level, including their patch size, distribution across the landscape, and connectivity.

Other habitats at the land-water interface -- Similar consideration of ecosystem services and the needed area and distribution should be given to other critical habitat types in the restored Bay-Delta ecosystem, including vernal pools, tall and short-grass prairie, floodplains, shallow sub-tidal habitats, etc.) Among them, these habitats also supported important ecosystem functions, including groundwater recharge, water filtration, nutrient and energy cycling, export of food items, and production of valuable plant and wildlife species. In order to support the abundance, distribution, and productivity targets identified for Public Trust species and the level of ecosystem functions appropriate to a restored Delta ecosystem, the Delta Plan should identify target abundances (acreages) and distributions (separation and minimum size of habitat patches) for key habitat types and target levels for the ecosystem services provided by these habitats. The best available information suggests that the restoration targets in Table 3 can be attained and are on the appropriate order of magnitude to facilitate ecosystem restoration – further work is required to specifically link these acreages to the production of other ecological targets.

Pelagic Habitat -- Pelagic habitats (i.e. open water, where habitat characteristics are not defined by the land-water interface) also require restoration and protection in the Bay-delta. In particular, Kimmerer et al. (2009) demonstrated that winter-spring outflows increased habitat for a number of estuarine dependent species with significant flow-abundance relationships. The flow-habitat relationship they found was of a scale capable of explaining the significant flow-to-abundance relationship for American shad and the flow-to-abundance and flow-to-survival relationship for striped bass. Feyrer et al (2007; 2010) demonstrated a similar fall flow-habitat relationship that was consistent with spatial distribution and abundance of Delta smelt and striped bass. Targets for pelagic habitats are also addressed in Table 3.

Water Quality – Various toxins may negatively impact the Bay-delta ecosystem and populations of target species, including:

- ammonium
- total ammonia
- pyrethroid and organophosphate insecticide (and other endocrine disrupting compounds)
- aquatic herbicide and terrestrial herbicide runoff
- metals and salts in agricultural and urban runoff
- methyl-mercury
- constituents of biochemical oxygen demand that may result in low DO events

Regulation and reduction of these and other compounds provides another excellent opportunity for the Delta Plan to affect ecosystem characteristics and target species populations that exceed levels in the recent historical record. Each category of potential target presents different challenges in terms of the need for and method of regulation. The precautionary principle dictates that certain potential toxins should be completely eliminated from the system entirely; other potential toxins cannot be effectively eliminated from the ecosystem and may be regulated either at their source or with regional cap-and-trade programs. We will present recommended water quality objectives for the Delta Plan at a later time, though we urge the Council not to ignore the need for water quality targets in the final Plan.

Category	Attribute	Interim Objective 1 (__ years from Plan Adoption)	Interim Objective 2 (__ years from Plan Adoption)	Interim Objective 3 (__ years from Plan Adoption)	Interim Objective 4 (__ years from Plan Adoption)	Total Objective (__ years from Plan Adoption)
Fresh Water Flow	Volume					Winter-Spring Flows *Actual Delta outflow = 75% of unimpaired Delta Outflow during Jan-June *Actual Rio Vista inflow = 75% of unimpaired Sacramento River inflow during Nov-June; *Min. 20,000cfs pulse flow at Wilkins Slough for ≥10 days (Nov-Jan); *Flows downstream of Georgiana Slough 13,000 to 17,000 cfs (Nov-June), *Actual Vernalis inflow = 60% of unimpaired SJR inflow (Feb-June); *4:1 inflow to export ratio (March-June) *Rio Vista: 2006 Bay-Delta Plan flows (Sept-Oct) Fall Flows *Min 10-day pulse flow of 3600 cfs at Vernalis (Oct) *Vernalis 10 day min pulse flow of 3,600 cfs (late Oct) *Rio Vista: 2006 Bay-Delta Plan flows (Sep-Oct)
	Timing Variability Frequency					Flows expressed as a % of the 7-day running average of unimpaired flows
	Source					Sacramento Basin (including Mokelumne) All major watersheds contribute 75% of their unimpaired flow; 14 day avg. of unimpaired; (Nov-June) (excludes Sacramento R. above RBDD2) San Joaquin Basin (including Calaveras) All major watersheds contribute ≥60% of their unimpaired flow; 14 day avg. of unimpaired; (Nov-June)
Habitat	Areal Extent	**e.g. Fall (Sept-Nov) Low Salinity Zone** X2≤83Km in 100% of years, <80Km in 80% of years, <77Km in 60% of years, <74Km in 40% of years, <71Km in 20% of years				
	Connectivity					
	Patch Size					
	Productivity					
Water Quality	Dissolved Oxygen					
	Pesticides (Insecticides, Herbicides, Fungicides, etc)					
	Selenium					
	Methylmercury					
	Endocrine Disrupting Compounds					
	Ammonium					

TABLE 3: Draft Proposed Delta Plan recovery objectives for key ecosystem attributes. Key attributes are identified though most interim final objectives have not yet been populated. If interim objectives for target species (Tables 1 and 2) are met completely, then certain interim targets for ecosystem attributes may be relaxed (so long as their relaxation can be shown not to interfere with subsequent species and ecosystem restoration targets).

[1]Ecosystem objectives are intended to support goals for anadromous and pelagic species including, but not limited to, the quantitative objectives identified for salmonids and pelagic species.

[2]Sacramento is excepted only if restoration of spatially distinct populations of winter-run Chinook salmon (i.e. where spawning success is not reliant on temperatures in the Sacramento R. mainstem) is unsuccessful

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