State of California
State Water Resources Control Board
DIVISION OF WATER RIGHTS
P.O. Box 2000, Sacramento, CA 95812-2000
Info: (916) 341-5300, FAX: (916) 341-5400, Web: http://www.waterboards.ca.gov/waterrights

PROTEST– PETITION

This form may also be used for objections

PETITION FOR TIME EXTENSION, CHANGE, TEMPORARY URGENT CHANGE OR TRANSFER ON

Water Right Permits 16478, 16479, 16481, and 16482 (Applications 5630, 14443, 14445A, and 17512, respectively) of the California Department of Water Resources for the State Water Project; and Water Right Permits 11315, 11316, 11967, 11968, 11969, 11971, 11973, 12364, 12721, 12722, and 12723 (Applications 13370, 13371, 5628, 15374, 15375, 16767, 17374, 17376, 5626, 9363, and 9364, respectively) of the U.S. Bureau of Reclamation for the Central Valley Project.

I (We) have carefully read the notice (state name): Kate Poole, Natural Resources Defense Council; Gary Bobker, The Bay Institute; Rachel Zwillinger, Defenders of Wildlife

Address, email address and phone number of protestant or authorized agent: Natural Resources Defense Council, 111 Sutter Street, 20th Floor, San Francisco, CA 94104, (415) 875-6100, kpoole@nrdc.org; The Bay Institute, Pier 39, Box #200, San Francisco, CA 94133, (415) 272-6616, bobker@bay.org; Defenders of Wildlife, 1303 J St., Suite 270, Sacramento, CA 95814, (916) 313-5800 rzwillinger@defenders.org

Attach supplemental sheets as needed. To simplify this form, all references herein are to protests and protestants although the form may be used to file comments on temporary urgent changes and transfers.

Protest based on ENVIRONMENTAL OR PUBLIC INTEREST CONSIDERATIONS (Prior right protests should be completed in the section below):

· the proposed action will not be within the State Water Resources Control Board's jurisdiction ☐

· not best serve the public interest ☒

· be contrary to law ☒

· have an adverse environmental impact ☒

State facts which support the foregoing allegations: See attached

Under what conditions may this protest be disregarded and dismissed? (Conditions should be of a nature that the petitioner can address and may include mitigation measures.): See attached

Protest based on INJURY TO PRIOR RIGHTS:

To the best of my (our) information and belief the proposed change or transfer will result in injury as follows:______________________________

Protestant claims a right to the use of water from the source from which petitioner is diverting, or proposes to divert, which right is based on (identify type of right protestant claims, such as permit, license, pre-1914 appropriative or riparian right):____________________

List permit or license or statement of diversion and use numbers, which cover your use of water (if adjudicated right, list decree).

____

Where is your diversion point located?_ ¼ of ____ ¼ of Section , T ___, R____, ___ B&M

If new point of diversion is being requested, is your point of diversion downstream from petitioner's proposed point of diversion? ____________________

The extent of present and past use of water by protestant or his predecessors in interest is as follows:

a. Source ____________________

b. Approximate date first use made____________________

c. Amount used (list units)____________________

d. Diversion season____________________

e. Purpose(s) of use____________________

Under what conditions may this protest be disregarded and dismissed?____________________

All protests must be signed by the protestant or authorized representative:

Signed: [signature] Date: January 5, 2016

Signed: [signature] Date: January 5, 2016

Signed: [signature] Date: January 5, 2016

All protests must be served on the petitioner. Provide the date served and method of service used:

Service via email to James.Mizell@water.ca.gov and Amy.Aufdemberge@sol.doi.gov on 1/5/2016

Information and Statement of Facts in Support of Protest of WaterFix Petition
Submitted by the Natural Resources Defense Council, The Bay Institute, and Defenders of Wildlife

I. Introduction:

Our organizations hereby protest the August 25, 2015 Petition by the Department of Water Resources and U.S. Bureau of Reclamation to change the point of diversion for the federal Central Valley Project (CVP) and State Water Project (SWP) as part of the California WaterFix Project ("Petition"), because the best available scientific data and information demonstrates that granting the Petition would cause unreasonable impacts on fish and wildlife, would be contrary to various state policies and laws, and is not in the public interest. Consistent with our Notice of Intent to Appear, our organizations intend to provide witness testimony on the unreasonable impacts to fish and wildlife and other beneficial uses of the waters of the San Francisco Bay-Delta estuary and upstream areas that would be caused by granting the Petition, as well as testimony on the availability of water supply from alternative projects.

This document and exhibits provide initial information in support of our protest. However, our testimony and subsequent submissions in this proceeding may raise additional issues that are not addressed in this statement of facts because the State Water Resources Control Board ("Board") has explicitly stated in the Notice of Petition Requesting Changes in Water Rights of the Department of Water Resources and U.S. Bureau of Reclamation for the California WaterFix Project ("Notice") that, "Persons wishing to participate in the hearing do not need to submit a protest against the Petition." *See* Notice at 3.

The Board must deny the Petition because it would cause unreasonable impacts on fish and wildlife, is contrary to law, and is not in the public interest.

II. Scope of the Board's Review of the Petition:

As discussed in more detail below, the Board is required to consider the full range of impacts of the proposed operations of the CVP and SWP with the change in point of diversion, in light of the Board's obligations under the Public Trust doctrine, section 85086(c)(2) of the Water Code, and other requirements of law.[1] The scope of the Board's review lawfully cannot be limited to the incremental, additional harm caused by the additional point of diversion or incremental changes to project operations. Instead, the Board must consider the full range of impacts on fish and wildlife and other beneficial uses from the operations of the State Water Project and Central Valley Project as proposed in the Petition and environmental documents, in order to determine if the proposed operations would result in unreasonable impacts on fish and wildlife. This includes both impacts from upstream operations as well as impacts in and downstream of the Delta from the new point of diversion. In order

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[1] Our prior comments to the Board regarding the duty to complete Phase 2 of the periodic review and update of the Bay-Delta Water Quality Control Plan prior to completing this proceeding are attached hereto as Exhibit A.

to grant the Petition, the Board must include conditions that are sufficient to ensure that: (a) existing water quality standards are achieved (including the narrative objective for salmon protection); and, (b) cumulative effects of the operations of the CVP and SWP will not cause unreasonable impacts to fish, wildlife, and water quality or jeopardize the continued existence or recovery of species, including upstream impacts from reservoir operations and/or impacts that are not limited to the incremental effect of the change in point of diversion.

A. The Board's Review Cannot be Limited to the Incremental Additional Harm Caused by the Change in Point of Diversion

Numerous decisions of the Board on petitions to change the point of diversion indicate that such a decision implicates the Board's obligations under the Public Trust doctrine, and as such, that review of the Petition is not limited to the incremental harm caused by the change petition. For instance, in 2015, the Board concluded that,

> "A change petition must also be in the public interest and not unreasonably harm fish, wildlife and other instream beneficial uses. . . . [T]he State Water Board has an independent obligation to consider the effect of the proposed project on public trust resources and to protect those resources where feasible."

In the Matter of Permit 10477, 2015 WL 4517569, at *9, 22 (March 30, 2015). In that order the Board noted that,

> The State Water Board is obligated to place into water rights "such terms and conditions as in its judgment will best develop, conserve and utilize in the public interest the water sought to be appropriated." (Wat. Code, § 1253; see also Wat. Code, § 1257.) The Board's ability to condition permits and enforce those terms authority is integral to the State Water Board's ability to fulfill its public trust obligations, and it is state policy that the State Water Board enforce permit terms and conditions "vigorously." (Wat. Code, § § 1253, 1825.)… If the flows necessary to protect the public trust are higher than the flows required by the permit, the State Water Board would lose permit enforcement authority as a tool to ensure that the public trust is protected at the appropriate level.

Id. at *13.

Under the Public Trust doctrine, the Board is compelled to consider the full range of impacts of CVP and SWP operations as proposed with the change in point of diversion, even if that requires reconsideration of the Board's prior decisions. As the Board wrote in its 2010 report on Development of Flow Criteria for the Sacramento-San Joaquin Delta Ecosystem:

> The State Water Board has continuing authority over water right permits and licenses it issues. In the exercise of that authority and duty, the State Water Board may, if appropriate, amend terms and conditions of water right permits and licenses to impose further limitations on the diversion and use of water by the water right holder to protect public trust uses or to meet water quality and flow objectives in Water Quality Control Plans it has adopted. The State Water Board must provide notice to the water permit or license holder and an opportunity for hearing before it may amend a water right permit or license.
>
> If the DWR and/or the USBR in the future request the State Water Board to amend the water right permits for the State Water Project (SWP) and/or the Central Valley Project (CVP) to move the authorized points of diversion for the projects from the southern Delta to the Sacramento River, Water Code section 85086 directs the State Water Board to include in any order approving a change in the point of the diversion of the projects appropriate Delta flow criteria. At that time, the State Water Board will determine appropriate permit terms and conditions. That decision will be informed by the analysis in this report, but will also take many other factors into consideration, including any newly developed scientific information, habitat conditions at the time, and other policies of the State, including the relative benefit to be derived from all beneficial uses of water. The flow criteria in this report are not pre-decisional in regard to any State Water Board action. (See e.g., Wat. Code, § 85086, subd. (c)(1).)

SWRCB, Development of Flow Criteria for the Sacramento-San Joaquin Delta Ecosystem (August 3, 2010) at 3-4.

Pursuant to the Board's obligations under the Public Trust, in acting on other change petitions the Board has imposed new conditions to protect fish and wildlife that were not limited to the incremental effects of a change in point of diversion. For instance, in Water Rights Order 95-03, the Board approved a change in point of diversion permit, but only after including a new condition on the permit to reserve the Board's continued authority under the Public Trust. Even though the Board found that flows below the dam would not be diminished as a result of granting the change petition, and therefore that there would not be any additional, incremental harm from granting the change petition, the Board exercised its responsibilities under the Public Trust to impose this new condition to potentially reduce diversions in the future to protect salmon on the Merced River.

Similarly, in Water Rights Order 2009-0015, the Board approved a petition to change the place of use, purpose of use, and points of rediversion, but only after adding a new condition (Condition 8) establishing minimum streamflows to prevent unreasonable harm to fish and wildlife and to protect public trust resources. There is no indication from this order that Condition 8 related solely to the incremental harm from the change in point of diversion.

In other contexts, the Board has concluded that "The State Water Board has an obligation to consider the public trust when conditioning or approving any diversion of water." In the Matter of License 7979 (Application 20301) of Irv Leen, SWRCB Feb. 3, 2013 (2013 WL 596457) (citations omitted). Similarly, in Water Rights Order 2009-0033, the Board referenced its "continuing duty to consider the impacts of water diversions on public trust resources, including fish and wildlife habitat" and cited D-1641 for the conclusion that "when reviewing a proposed change to a permit or license, the Board should consider the same factors that were considered when reviewing the underlying water right application, and therefore the Board should consider the public interest and effects on fish and wildlife." Because DWR and the Bureau of Reclamation have petitioned the Board for the change in point of diversion, they have necessarily triggered the Board's obligations under the Public Trust doctrine, and the Board must consider the full range of impacts of CVP/SWP operations as proposed with the change in point of diversion. The Board's review cannot be limited to the incremental effects of the change in point of diversion without violating its obligations under the Public Trust doctrine.

B. The Board's Review of the Impacts on Fish and Wildlife Cannot be Limited to Consistency with Existing Water Quality Standards

In addition, the Board's review of impacts cannot be limited to compliance with existing water quality standards. As the Board itself has indicated, the existing standards in the Bay-Delta Water Quality Control Plan fail to protect public trust resources including fish and wildlife. For instance, the Board has previously determined that "[t]he best available science suggests that current flows are insufficient to protect public trust resources." SWRCB, Development of Flow Criteria for the Sacramento-San Joaquin Delta Ecosystem (August 3, 2010) at 2; *id*. at 5 (acknowledging that "[r]ecent Delta flows are insufficient to support native Delta fishes for today's habitats"); *see* SWRCB Resolution 2010-0039 ("In accordance with the Delta Reform Act, the State Water Board approves the report determining new flow criteria for the Delta ecosystem that are necessary to protect public trust resources."). In addition, by adopting Resolution 2009-0065, the Board approved the staff report on periodic review of the Bay-Delta Water Quality Control Plan, which recommends numerous changes to existing flow and water quality standards, recognizing that existing standards fail to adequately protect fish and wildlife. *See* Staff Report, Periodic Review of the 2006 Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary at 19 ("The available information indicates that further review and change of Delta outflow objectives may be required. Changes to Delta outflow patterns have likely contributed to the POD and are likely having an impact on the abundance of other species of concern. Actions taken under the federal ESA are already changing outflow requirements for the SWP and CVP and additional species protection actions are imminent."); *id*. at 21 ("The available information indicates that new or changed export limits may be necessary to adequately protect beneficial uses in the Delta. Recent analyses of the impact of export pumping on Delta fish species of concern show that more restrictive limits may be required."); *id*. at 26 ("The continued decline in the populations of several Delta fish species, as indicated by reductions in survey indices (Armor et al. 2007), also suggests that the export limits in the Bay-Delta Plan are not sufficient to protect aquatic species.").

Other agencies have also concluded that existing water quality standards are inadequate to protect native fish species and other Public Trust resources, including preventing the extinction of native fish species. *See, e.g.*, CDFW 2010 flow objectives report; CDFW May 2, 2012 comment letter to SWRCB regarding Phase II; Environmental Protection Agency 2012 Bay Delta Action Plan at 7 (stating that "Despite much ongoing activity, CWA programs are not adequately protecting Bay Delta Estuary aquatic resources, as evidenced by the pelagic organism decline."); *id*. at 9-11 (stating that many designated uses are currently impaired, and directing the Board to expeditiously modify estuarine habitat protection standards in the Bay Delta Water Quality Control Plan to more fully protect aquatic species); FWS 2008 biological opinion;[2] NOAA 2009 biological opinion; NOAA April 25, 2012 comments to the SWRCB regarding Phase II; Delta Stewardship Council 2013 Delta Plan at 133, 148. As noted in our prior comments to the SWRCB regarding the update of the Bay-Delta Water Quality Control Plan, which are attached hereto as Exhibit B, existing water quality standards are inadequate to reasonably protect fish and wildlife, and operations of the CVP and SWP that jeopardize the continued existence of native fisheries result in unreasonable impacts on fish and wildlife. *See* Exhibit B (Submission 3 at 7-9). And the cases cited above also demonstrate that the Board can include new conditions to protect fish and wildlife that are not limited to compliance with existing water quality standards. *See* Water Rights Order 95-03; Water Rights Order 2009-0015. Our prior comments to the SWRCB included as Exhibit B provide additional scientific information on the inadequacy of existing water quality standards to protect fish and wildlife, and recommendations regarding changes to water quality standards necessary for reasonable protection of fish and wildlife in the Bay-Delta watershed. *See* Exhibit B (Submissions 1 and 2).

In addition, the Delta Reform Act of 2009 requires that the Board impose "appropriate" flow criteria, which are to be informed by the Board's 2010 Public Trust Flow report, before approving any petition seeking a change in point of diversion for the CVP and SWP. Water Code § 85086(c)(2). Such review cannot be limited to existing water quality standards. It is unclear from the Notice whether the Board's adoption of appropriate flow criteria pursuant to section 85086(c)(2), including Sacramento River bypass flows and Delta outflows, will include only those flows that are the responsibility of the CVP and SWP to contribute, or whether it will include flows from other sources. DWR and Reclamation currently bear responsibility for meeting all of the flow objectives in the water quality control plan. The Board must specify whether flow criteria under section 85086(c)(2) includes only flows that are the future responsibility of the CVP and SWP (such that additional outflows and bypass flows may be required from other water rights holders), or whether it includes flows that may be the responsibility of other water rights holders.

[2] The biological opinions from the U.S. Fish and Wildlife Service and National Marine Fisheries Service concluded that implementation of existing water quality standards under D-1641, without implementation of the Reasonable and Prudent Alternative in each biological opinion, would jeopardize the continued existence and recovery of species listed under the federal Endangered Species Act. This demonstrates that the water quality standards are insufficient even to avoid jeopardy of endangered species, much less to meet the Board's obligations under the Public Trust doctrine.

C. The Board Must Ensure that the Narrative Objective for Salmon Protection will be met in Order to Avoid Unreasonable Impacts on Fish and Wildlife

The Board must ensure that the Petition is consistent with, and will achieve, the narrative salmon protection objective in the existing Bay-Delta Water Quality Control Plan ("to achieve a doubling of natural production of Chinook salmon from the average production of 1967-1991, consistent with the provisions of State and federal law"). The failure to achieve this objective would constitute an unreasonable injury to fish and wildlife, as the narrative salmon protection objective constitutes a legislative and policy determination of California's obligations under the Public Trust doctrine. *See* Exhibit B (Submission 3 at 10-11).

D. The Board Must Ensure Compliance with the California Endangered Species Act and the Prevention of Extinction of Endangered Species in Order to Avoid Unreasonable Impacts on Fish and Wildlife

The Board must ensure that the Petition is consistent with the California Endangered Species Act ("CESA"), including CESA's requirement to avoid driving native fish and wildlife species to extinction.[3] The failure to comply with CESA would constitute an unreasonable injury to fish and wildlife, which is not subject to balancing. *See* Exhibit B (Submission 3 at 7-9). Because operations as proposed in the Petition would jeopardize the continued existence and recovery of several native fish species, granting the Petition would violate state and federal laws including the ESA and CESA.

E. The Board Must Consider the Impact of Future Waivers of Water Quality Standards on Fish and Wildlife

The durability of protections for fish and wildlife is also a significant issue that the Board must address in this proceeding. Over the past several years the Board has repeatedly waived and failed to enforce existing water quality standards, and state and federal agencies have repeatedly waived requirements of the ESA and CESA. This has caused unreasonable impacts to fish and wildlife species, in some cases driving species to the very brink of extinction. The Board must analyze the potential impacts to fish and wildlife if minimum conditions and standards are waived in future droughts, and must demonstrate how future waivers of these protections will be avoided in order to ensure that granting the petition is not likely to result in unreasonable impacts to fish and wildlife in the future.

F. The Board Must Assess the Availability of Alternative Water Supplies in this Proceeding

Finally, in order to determine the reasonableness of protections for fish and wildlife and other beneficial uses, and other water users, as well as the public interest in the Petition, the Board must consider the availability of alternative water supplies including water recycling, water conservation and efficiency,

[3] Petitioners must also demonstrate that operations as proposed in the Petition are consistent with their legal obligations under section 5937 of the Fish and Game Code. *See* Water Code § 1701.3(b)(2).

stormwater capture, and reservoir re-operation. *See* Decision 1485 at 16-19; Decision 1631 at 165-168, 176-177; Water Rights Order 2009-0034EXEC; Exhibit B (Submission 3 at 3-7); *see also* Water Code § 13241(f).

The Board's decision on the Petition also must comply with section 85021 of the Water Code, which requires that agencies reduce reliance on water supplies from the Bay-Delta and invest in regional self-sufficiency. The 2014 report by NRDC and the Pacific Institute entitled Untapped Potential provides initial information regarding the availability of alternative water supplies to reduce reliance on the Delta and improve flows to protect fish and wildlife. It is attached hereto as Exhibit C. We intend to call one or more witnesses to testify regarding alternative water supplies.

III. <u>The Supplemental Draft Environmental Impact Report Fails to Comply with CEQA and Must be Revised and Recirculated:</u>

As a responsible agency, the Board must independently review the adequacy of the Revised Draft Environmental Impact Report (RDEIR) under the California Environmental Quality Act. As noted in our organizations' comments on the CEQA documents (attached hereto as Exhibits D and E), the DEIR and RDEIR fail to comply with CEQA, particularly with respect to the effects of climate change, the range of alternatives that are analyzed, and the analysis of environmental impacts.

Prior to initiating Part II of this water rights proceeding, the Board must ensure that the RDEIR is revised and recirculated, including but not limited to analysis of the potential environmental impacts of the operational provisions included in Appendix B to the CEQA document. In prior proceedings, the Board has concluded that, "The State Water Resources Control Board cannot conduct a hearing on the petitions until the EIR is completed." Water Rights Order 79-20, July 19, 1979, 1979 WL 24780).

IV. <u>The Board Must Ensure Part II of this Proceeding Does Not Begin Until at Least 90 Days Following Completion of all CESA/ESA permits / biological opinions and NEPA/CEQA documents:</u>

The Notice indicates that Part II of this proceeding will commence at least 30 days "following completion of environmental and endangered species act compliance for the project." Notice at 1, 2. We strongly agree that Part II of this proceeding should not commence until the public and protestants have sufficient time to review the environmental and endangered species act compliance for the project. However, 30 days is insufficient time to allow protestants and the public to review and incorporate the information from these complex documents into our testimony and prepare for cross-examination of witnesses. We request that the Board order that Part II of this proceeding will not begin until at least 90 days after all of the following permits and environmental documents are completed and made available for public review:

- The new biological opinions issued by the U.S. Fish and Wildlife Service and National Marine Fisheries Service for the WaterFix Project;
- The new CESA permit issued by the California Department of Fish and Wildlife for take of longfin smelt by the WaterFix Project;
- The revised and recirculated final CEQA and NEPA documents for the WaterFix Project;
- The Clean Water Act section 404 permit issued by the Army Corps of Engineers for the Project; and,
- The Record of Decision for the Project.

In order to allow for orderly administration of this proceeding, and in light of the time needed to complete these processes, the Board should determine that Part II will not start before January 1, 2017, and will not commence until 90 days after completion of all of these permits and reviews.

V. **The Best Available Science Demonstrates that Granting the Petition will Cause Unreasonable Impacts to Fish and Wildlife:**

As discussed in detail in our comments on the CEQA/NEPA documents, the best available scientific data and information demonstrates that granting the Petition will cause unreasonable impacts on fish and wildlife, including but not limited to continued declines and potential extinction of fish species listed as endangered or threatened under the ESA and CESA and severe degradation and potential loss of environmental water quality, estuarine habitat and fish migration for a broad range of Bay-Delta fish and wildlife species.

A. Granting the Petition Will Cause Unreasonable Impacts to Winter Run Chinook Salmon

As discussed in our comments on the CEQA/NEPA documents, granting the Petition is likely to reduce survival of winter run Chinook salmon through the Delta as compared to the status quo, as a result of operations of the new points of diversion. Exhibit E at 36, 38-39, 72-76; Exhibit D at 176-178. The reduction in sediment supply and turbidity in the lower Sacramento River, Delta, and San Francisco Bay, increases in residence time of water flowing through the Delta, and increases in harmful algal blooms in the Delta and the spread of their toxins to the rest of the estuary, as a result of granting the petition, would also cause significant adverse impacts to winter run Chinook salmon. Exhibit E at 51-59, 72-73. Granting the Petition is also likely to significantly increase predation of winter run Chinook salmon at and downstream of the new points of diversion, reducing survival and abundance. *See* Exhibit E at 73-75. These incremental effects of the Petition constitute unreasonable impacts on fish and wildlife.

In addition, the CEQA/NEPA documents demonstrate that operations of the CVP and SWP as proposed in the Petition, in combination with the effects of climate change, will significantly increase mortality of winter run Chinook salmon below Shasta Dam, threatening the continued existence of this species. *See* Exhibit E at 16-18, 36-38, 77-80; Exhibit D at 169-176. Moreover, operations as proposed in the Petition are not likely to achieve the narrative salmon protection objective in the Bay-Delta Water Quality

Control Plan, as it pertains to winter-run Chinook salmon, as the modeling and other information indicates that winter run Chinook salmon populations are likely to continue to decline in abundance. *See* Exhibit E at 16-18, 36-39, 51-59, 72-75, 77-80; Exhibit D at 162-179. These cumulative effects of the Petition and CVP/SWP operations on winter run Chinook salmon, in combination with the effects of climate change, constitute unreasonable effects on fish and wildlife.

B. Granting the Petition Will Cause Unreasonable Impacts to Fall Run Chinook Salmon

As discussed in our comments on the CEQA/NEPA documents, granting the Petition is likely to reduce survival of fall run Chinook salmon through the Delta as compared to the status quo, as a result of operations of the new point of diversion. Exhibit E at 42-43, 72-76; Exhibit D at 214-215. This is also true for fall run Chinook salmon migrating from the San Joaquin River basin, where the CEQA/NEPA documents demonstrate that granting the Petition would significantly reduce survival through the Delta and subsequent abundance. Exhibit E at 76-77. The reduction in sediment supply and turbidity in the lower Sacramento River, Delta, and San Francisco Bay, increases in residence time of water flowing through the Delta, and increases in harmful algal blooms in the Delta and the spread of their toxins to the rest of the estuary, as a result of granting the petition, would also cause significant adverse impacts to fall run Chinook salmon. Exhibit E at 51-59, 72-73. Granting the Petition is also likely to significantly increase predation of fall run Chinook salmon at the new point of diversion, reducing survival and abundance. *See* Exhibit E at 73-75. These incremental effects of the Petition constitute unreasonable impacts on fish and wildlife.

In addition, the CEQA/NEPA documents demonstrate that operations of the CVP and SWP as proposed in the Petition, in combination with the effects of climate change, will significantly increase mortality of fall run Chinook salmon upstream of the Delta. *See* Exhibit E at 16-18, 41, 75-77, 79-80; Exhibit D at 209-215. Moreover, operations as proposed in the Petition are not likely to achieve the narrative salmon protection objective in the Bay-Delta Water Quality Control Plan, as it pertains to fall-run Chinook salmon, based on the modeling and information presented. *See id*. These cumulative effects of the Petition and CVP/SWP operations on fall run Chinook salmon, in combination with the effects of climate change, constitute unreasonable effects on fish and wildlife.

C. Granting the Petition Will Cause Unreasonable Impacts to Spring Run Chinook Salmon

As discussed in our comments on the CEQA/NEPA documents, granting the Petition is likely to reduce survival of spring run Chinook salmon through the Delta as compared to the status quo, as a result of operations of the new points of diversion. Exhibit E at 41, 72-76; *see* Exhibit D at 184-189. The reduction in sediment supply and turbidity in the lower Sacramento River, Delta, and San Francisco Bay, increases in residence time of water flowing through the Delta, and increases in harmful algal blooms in the Delta and the spread of their toxins to the rest of the estuary, as a result of granting the petition, would also cause significant adverse impacts to spring run Chinook salmon. Exhibit E at 51-59, 72-73. Granting the Petition is also likely to significantly increase predation of spring run Chinook salmon at the new points of diversion, reducing survival and abundance. *See* Exhibit E at 73-75. These incremental effects of the Petition constitute unreasonable impacts on fish and wildlife.

In addition, the CEQA/NEPA documents demonstrate that operations of the CVP and SWP as proposed in the Petition, in combination with the effects of climate change, will significantly increase mortality of spring run Chinook salmon upstream of the Delta. *See* Exhibit E at 16-18, 39-41, 72-77. Moreover, operations as proposed in the petition are not likely to achieve the salmon doubling objective in the Bay-Delta Water Quality Control Plan. *See id*. These cumulative effects of the Petition and CVP/SWP operations on fall run Chinook salmon, in combination with the effects of climate change, constitute unreasonable effects on fish and wildlife.

D. Granting the Petition Will Cause Unreasonable Impacts to Steelhead

As discussed in our comments on the CEQA/NEPA documents, granting the Petition is likely to reduce migratory survival through the Delta, reduce sediment supply and turbidity, increase residence time, and increase harmful algal blooms, which would also cause significant adverse impacts to steelhead. Exhibit E at 44, 51-59, 72-73. These incremental effects of the Petition as compared to the status quo constitute unreasonable impacts on fish and wildlife. In addition, operations as proposed in the Petition, in combination with the effects of climate change, will significantly increase mortality and reduce survival of steelhead upstream of the Delta. Exhibit E at 16-18, 43-44, 75-76. These cumulative effects of the Petition constitute an unreasonable effect on fish and wildlife.

E. Granting the Petition Will Cause Unreasonable Impacts to Green and White Sturgeon

As discussed in our comments on the CEQA/NEPA documents, granting the Petition is likely to reduce survival and abundance of Green and White Sturgeon as compared to the status quo, as a result of the reduction in critical flows due to the new intakes, as well as from increased predation, reduced turbidity, and increased harmful algal blooms. Exhibit E at 45-47, 51-59. Granting the Petition also is likely to result in substantial adverse effects on White and Green Sturgeon through increased exposure to selenium and other contaminants. Exhibit E at 49-50. These incremental effects of the Petition constitute unreasonable impacts on fish and wildlife.

In addition, the CEQA/NEPA documents demonstrate that operations of the CVP and SWP as proposed in the Petition, in combination with the effects of climate change, will significantly harm Green and White Sturgeon upstream of the Delta, including reductions in the productivity of both species. *See* Exhibit E at 16-18, 46-47, 77-78.

F. Granting the Petition Will Cause Unreasonable Impacts to Delta Smelt

As discussed in our comments on the CEQA/NEPA documents, granting the Petition is likely to reduce the abundance of Delta Smelt as compared to the status quo, because granting the Petition will reduce turbidity, increase the frequency of harmful algal blooms, increase predation pressure, increase invasive aquatic vegetation, reduce Delta outflows in the spring and fall months, and increase entrainment of Delta Smelt in some years. Exhibit E at 51-57, 61-64; Exhibit D at 215-233. These incremental effects constitute unreasonable effects on fish and wildlife. It is clear from the CEQA/NEPA documents that operation of the CVP and SWP as proposed in the Petition is not likely to reverse the decline of Delta Smelt, is likely to impair recovery, and will likely lead to extinction in violation of state and federal laws. These cumulative effects constitute unreasonable effects on fish and wildlife.

G. Granting the Petition Will Cause Unreasonable Impacts to Longfin Smelt

As discussed in our comments on the CEQA/NEPA documents, granting the Petition is likely to reduce the abundance of longfin smelt because of the reduction in winter-spring outflows below currently impaired levels. Exhibit E at 64-71; *see* Exhibit D at 129-149. As noted in our comments, simply maintaining existing levels of winter to spring Delta outflows is likely to lead to continued declines in abundance of this species and its consequent listing under the federal Endangered Species Act. *Id*. In addition, granting the Petition will also result in significant adverse impacts to longfin smelt because of the reductions in turbidity, increases in the frequency of harmful algal blooms, increases in predation pressure, and increases in invasive aquatic vegetation associated with the new point of diversion. Exhibit E at 51-57. These effects, both incrementally and cumulatively, constitute unreasonable effects on fish and wildlife.

VI. <u>Granting the Petition is Not in the Public Interest:</u>

A. Unreasonable Impacts to Fish and Wildlife

As discussed above and in our comments on the NEPA/CEQA documents, granting the petition will cause unreasonable impacts to fish and wildlife. In addition to CESA/ESA-listed species and fall run Chinook salmon identified above, operations under the proposed project are likely to harm fisheries including those for White Sturgeon and Starry Flounder and the prey base for many native fish and wildlife species, including bay shrimp, opossum shrimp, and copepods. Furthermore, declines in the fish and wildlife species mentioned above (and others) are expected to have a negative impact on wildlife including diving ducks, pelagic piscivorous birds of the San Francisco Estuary, and local marine mammal populations. Moreover, construction of the proposed project may reduce available habitat for birds and other wildlife that utilize Delta islands (e.g., Sandhill Cranes), and project operations may reduce the amount of water available for state, federal, and private wildlife refuges in the Central Valley that support several threatened and endangered species and millions of migratory birds. Finally, the proposed project's impact on sediment supplies to the Delta and estuary is likely to have negative effects on the ability to restore shallow intertidal habitats and the plant and wildlife species that rely on these habitats. As a result of these impacts, including impacts to species listed under CESA and the ESA, granting the Petition is not in the public interest.

B. Unreasonable Impacts to Water Quality

As discussed in detail in our comments on the NEPA/CEQA documents, granting the petition will cause significant and unreasonable impacts to water quality in the Delta, which will impair numerous beneficial uses. In addition, even where such adverse changes may not result in violations of existing water quality standards, the Board must consider whether such impacts violate the antidegradation policy (which is part of the water quality standards of the State).

The RDEIR/SDEIS demonstrates that CVP/SWP operations with the new point of diversion proposed in the Petition will substantially reduce sediment supply to the Delta, San Francisco Bay, and Suisun Marsh. *See* Exhibit E at 52-54, 64, 87-88. This will substantially reduce turbidity in these waterbodies. *Id*. The RDEIR/SDEIS also demonstrates that the new point of diversion will increase residence time in the Delta. *Id*. at 48, 55-58. The combination of increased water temperatures as a result of climate change, increased residence time, and reduced turbidity as a result of granting the petition is likely to caused increased outbreaks of harmful algal blooms, including *Microcystis*, which threaten agricultural beneficial uses, urban beneficial uses, fish and wildlife beneficial uses, and human health and safety. *Id*. at 48, 51-58, 87-89. The reduction in turbidity and sediment from granting the Petition will also cause substantial impacts on fish and wildlife, as discussed above.

In addition, other comments on the RDEIR/SDEIS demonstrate that granting the Petition is likely to substantially increase salinity in the Delta. This is particularly true during future droughts, where the RDEIR/SDEIS indicates that water quality standards and other protections for fish and wildlife cannot be met and are likely to be waived or weakened. *See* Exhibit E at 26-29. This is likely to harm fish and wildlife and other beneficial uses of water in the Bay-Delta.

C. Availability of Alternative Water Supplies

Millions of acre feet of new water supplies are available to CVP and SWP contractors from improved urban and agricultural water use efficiency, urban stormwater capture, wastewater recycling, and other tools. *See* Exhibit C; Exhibit B (Submission 3 at 3-7). The availability of these and other alternative water supplies demonstrate that reduced diversions from the Delta, and increased protections for fish and wildlife, are feasible, reasonable, and in the public interest.

D. Failure to Reduce Reliance on the Delta as Required by the Delta Reform Act

The 2009 Delta Reform Act establishes state policy to reduce reliance on water supplies from the Bay-Delta estuary, and to require investments in regional water supply solutions including water use efficiency, recycling, stormwater capture, and improved groundwater management. Water Code § 85021. The proponents have failed to demonstrate how the Petition reduces reliance on the Delta, and indeed, it appears to increase reliance on the Delta and the costs associated with the California WaterFix are likely to preclude investments in regional water supply solutions. *See* Exhibit E at 2, 7, 10.

E. Economic Benefits of Restoring the Delta Ecosystem and Fisheries

In assessing whether protections for fish and wildlife are reasonable, feasible and in the public interest, the Board must not limit its analysis to economic costs, but must provide equal consideration to the economic benefits of protecting the health of the Delta and its fish and wildlife populations. This includes assessing the economic benefits of sustaining and restoring sport and/or commercial fisheries for salmon, starry flounder, sturgeon and other native species, and the thousands of fishing and related jobs that depend on species that live or migrate through the Delta. It also includes the economic value of recreational activities in the Delta that would be affected by the Petition, such as birdwatching. In addition, the Board must consider the monetary value of a restored Delta ecosystem, including non-use values such as David Sunding's preliminary estimate of a present value of $12-53 billion. *See* Exhibit B (Submission 3 at 9-10). Although economic considerations do not trump the responsibility to protect Public Trust resources or comply with other environmental laws, the Board must explicitly consider these economic benefits in assessing the Petition; the magnitude of economic benefits from restoring the Delta support increased protections beyond those proposed in the Petition.

VII. <u>Potential Conditions to Resolve Protest</u>

The Board should analyze the effects of the potential conditions listed below, in order to avoid unreasonable impacts on fish and wildlife, comply with state and federal environmental laws, and act in the public interest. Identification of these potential conditions below is not an indication that they would resolve our protest, because additional modeling and analysis of these potential conditions is necessary to determine their effectiveness in avoiding unreasonable effects on fish and wildlife and meeting existing legal obligations.

(1) Require river inflows to the Delta and outflows from the Delta to San Francisco Bay at levels consistent with the findings of the 2010 flow criteria report regarding sufficient flows to fully protect public trust fish and wildlife resources, e.g., between 60 and 75% of unimpaired runoff from the Bay-Delta watershed;

(2) Limit the new point of diversion to 3,000 cfs diversion capacity;

(3) Mandate additional water conservation, water recycling, urban stormwater capture, and other regional water supply projects by CVP and SWP contractors in order to reduce reliance on the Delta and improve environmental and water supply outcomes;

(4) Impose revised reservoir operation rules to maintain adequate downstream temperatures during drought conditions, including mandatory minimum carryover storages and maximum annual drawdown limits in key reservoirs.

VIII. Conclusion

The Board should deny the Petition because: (1) the best available science demonstrates that granting the Petition will cause unreasonable impacts to fish and wildlife and worsen water quality in the Delta for multiple beneficial uses; (2) the social and economic benefits of restoring the Delta ecosystem outweigh the social and economic benefits of granting the Petition; (3) alternative water supplies are available and economically feasible, and the law requires project proponents to reduce reliance on water from the Delta and invest in regional water supplies including conservation and efficiency, stormwater capture, wastewater recycling, and improved groundwater management; and (4) existing documentation is incomplete and inadequate to completely evaluate the Petition.

September 29, 2015

Tom Howard
Executive Director, State Water Resources Control Board
1001 I Street
Sacramento, CA 95814

RE: Preliminary Comments Regarding the Notice, Fact Sheet and Petition for Change in Point of Diversion for the California WaterFix

Dear Mr. Howard:

On behalf of the Natural Resources Defense Council, Defenders of Wildlife, Golden Gate Salmon Association, Friends of San Francisco Estuary, and The Bay Institute, we are writing to provide preliminary comments regarding the State Water Resources Control Board's (SWRCB) notice relating to the California WaterFix. The notice and fact sheet indicate that the SWRCB will complete review of the change in point of diversion petition prior to the completion of phase 2 of the update of the Bay-Delta Water Quality Control Plan, and DWR's Petition states on pages 10-11 that the Board's review of the change petition will be limited to the existing Water Quality Control Plan and D-1641. As discussed below, this approach is unlawful, and the SWRCB must ensure completion of the update of the Bay-Delta Water Quality Control Plan with adequate flow and water quality objectives to protect fish and wildlife beneficial uses and public trust resources, prior to issuing any order approving a change in point of diversion.

Contrary to the statements in DWR's petition, [1] the Board cannot lawfully rely on the existing Bay-Delta Water Quality Control Plan and D-1641 in assessing injury to fish and wildlife beneficial uses and public

[1] DWR's petition states that, "Thus the WQCP and the water rights decisions stemming from implementation of the WQCP and earlier water quality plans, including D-1641, are protective of beneficial uses until replaced through

trust resources under the Water Code. The 2009 Delta Reform Act compels the SWRCB to adopt updated flow criteria in assessing whether the change petition would cause unreasonable injury to fish and wildlife, and the SWRCB has previously acknowledged that the water quality standards must be updated in order to review the change petition. In addition, numerous agencies – including the SWRCB – have concluded that existing flows under D-1641 and the existing water quality control plan fail to reasonably protect fish and wildlife beneficial uses and public trust resources.

First, the 2009 Delta Reform Act requires that the SWRCB adopt "appropriate" flow criteria for any change in point of diversion, rather than simply limiting review to D-1641 and the existing Water Quality Control Plan. The Act specifically requires the SWRCB to include, in any order approving a change in point of diversion, "appropriate Delta flow criteria" that shall be informed by the Public Trust Flow Report mandated by section 85086(b)(1) and which shall be subject to adaptive management. Cal. Water Code § 85086(b)(2). The legislative analysis of the bill supports this conclusion:

> This bill's "flow criteria" reflect a landmark concept of the state exercising its public trust authority to ask - FIRST - what the Delta needs, before completing plans for fundamental change to the nature of the Delta, as envisioned by the Bay Delta Conservation Plan….
>
> Paragraph (c)(2) specifies that certain water right change orders, involving specified changes in the points of diversion for the Central Valley Project or the State Water Project, must include "appropriate" Delta flow criteria. While the analysis used in developing flow criteria under paragraph (c)(1) will be considered in setting flow criteria under paragraph (c)(2), neither the analysis nor the criteria themselves predetermine the outcome of the later proceeding to determine what criteria are "appropriate" for inclusion in the water right change order. In addition, while the flow criteria developed under paragraph (c)(1) do not have regulatory effect - they serve instead as recommendations for consideration in the Delta Plan and the Bay Delta Conservation Plan - the flow criteria set under paragraph (c)(2) are included in the water right change order, and have the effect of terms and conditions of that order.
>
> This requirement for flow criteria should also be read in the context of the savings clauses in Water Code Sections 85031-32, which ensure protection for all water rights holders as the Bay Delta Conservation Plan and the Delta Plan develop. Several upstream parties have raised concerns about these flow criteria, suggesting that they will be held responsible for complying with these flow criteria. The combination of the focus on use of flow criteria early in Delta planning efforts, specified process for developing flow criteria, and the savings clauses ensure consistent legal protection for

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the update process and constitute the standard for determining injury to those beneficial uses when considering this Petition."

> upstream water users without rewriting water law to focus protections on specific concerns.

Assembly Floor Analysis, SB 7X 1, November 4, 2009.

Second, the SWRCB has already concluded that it must update the water quality control plan in order to assess impacts to beneficial uses from a change in point of diversion permit. In a January 25, 2012 letter,[2] the Executive Director of the Board denied requests by some stakeholders to delay issuance of a Notice of Preparation for review of Delta objectives, stating:

> There are three reasons I believe the State Water Board needs to issue the Supplemental NOP now. First, restoration of the Delta is an essential goal of the State. Numerous scientific documents have identified flow as a major factor affecting fisheries and other public trust uses of water in the Delta. The State Water Board is the State agency responsible for establishing water quality and flow objectives for the Bay-Delta to protect these uses. Second, the Delta Stewardship Council's draft Delta Plan includes direction to the State Water Board to adopt and implement flow objectives for the Delta by June of 2014. The Council is charged with pulling together all Delta activities into an integrated, coherent process. While the June 2014 target date will be very difficult to meet, the accelerated timeline is critical because flows are fundamental to Delta decision making. **Third, the Delta Reform Act specifies that no construction of Bay-Delta Conservation Plan (BDCP) facilities is allowed until the State Water Board approves any necessary changes in the point of diversion. A change in the point of diversion will require updated Delta flow objectives.** Because the State Water Board's flow-setting process can take several years, it must be conducted in parallel, rather than sequentially, to the BDCP process so as not to interfere with BDCP implementation.

(emphasis added).

Third, the SWRCB, California Department of Fish and Wildlife, Delta Stewardship Council, and other agencies and stakeholders have concluded that D-1641 and the existing water quality control plan fail to reasonably protect fish and wildlife beneficial uses and public trust resources in the Bay-Delta. For instance, the SWRCB's 2010 Public Trust Flows report explicitly states that, "The best available science suggests that current flows are insufficient to protect public trust resources."[3] Similarly, testimony and presentations to the SWRCB during Phase 1 and Phase 2 of the periodic review of the water quality control plan have demonstrated that existing flow and water quality standards are inadequate to

[2] This letter is available online at: http://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/bay_delta_plan/environmental_review/docs/cmp_rvw_cmmnt/swrcb_water_power_response_120125.pdf.

[3] Available online at: http://www.swrcb.ca.gov/waterrights/water_issues/programs/bay_delta/deltaflow/docs/final_rpt080310.pdf

reasonably protect native fish and wildlife species, their habitats, and the underlying conditions that support them. For instance, the May 12, 2012 comments from the California Department of Fish and Wildlife stated that, "Fish population declines coupled with these hydrologic and physical changes suggest that current Delta water flows for environmental resources are not adequate to maintain, recover, or restore the functions and processes that support native Delta fish,"[4] and the Department's presentation to the SWRCB explicitly states that the "Bay-Delta Plan [is] insufficiently protective of smelt species," including longfin smelt and delta smelt. [5]

Moreover, the issuance in recent years of new biological opinions under the federal Endangered Species Act, and consistency determinations and permits under the California Endangered Species Act, *per se* demonstrates that D-1641 and the existing water quality control plan fail to reasonably protect fish and wildlife. Indeed, although the CEQA/NEPA document for the California WaterFix is substantially flawed and legally defective, even it admits that the No Action Alternative will result in significant adverse impacts on native fish and wildlife including winter run Chinook salmon. *See* Bay Delta Conservation Plan/California WaterFix Partially Recirculated Draft EIR/ Supplemental Draft EIS, at ES-48 (identifying significant impacts of water operations on rearing habitat for covered fish species and significant and unavoidable impacts on spawning and egg incubation habitat for winter run Chinook salmon and green sturgeon).

Therefore, an assessment of the impact of the proposed California Water Fix on the standards and requirements described in the current Water Quality Control Plan and D-1641 fails to adequately assess the project's impact on protected fish and wildlife beneficial uses and public trust resources.

In addition, ensuring reasonable protection of fish and wildlife requires far more than meeting minimum ESA and CESA standards, and the SWRCB must also protect public trust resources to the extent feasible.[6] Similarly, the existing flow and water quality standards have proven inadequate to achieve the salmon doubling objective in the existing water quality control plan, and the Board must ensure that the "appropriate flows" required pursuant to section 85086(b)(2) will be sufficient to achieve this objective of the water quality control plan.[7] Alternative 4A in the California WaterFix fundamentally fails to meet

[4] Available online at: http://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/bay_delta_plan/comments_042512/scott_cantrell.pdf. In addition, the Department's 2010 report on biological objectives for the Delta reached an identical conclusion.

[5] Available online at: http://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/docs/wrkshp1/fishagencies.pdf

[6] For more information, please review the comments of the Natural Resources Defense Council and The Bay Institute to the SWRCB dated October 26, 2012, available online at: http://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/docs/comments111312/doug_obegi.pdf.

[7] DWR's petition also inappropriately asserts that the "appropriate flow criteria" required by the Delta Reform Act should likewise be limited to D-1641 and the existing water quality control plan, as well as the flows presented by Alternative 4A: "Consideration of this Petition under Water Code §85086(c)(2) should occur within the existing

the requirements of the ESA, CESA, and the salmon doubling objective of the existing Bay-Delta Water Quality Control Plan. The SWRCB must ensure that, should it eventually approve a change in point of diversion, it includes conditions sufficient to ensure achievement of the salmon doubling objective of the existing Bay-Delta Water Quality Control Plan.

In conclusion, the SWRCB must complete its periodic review of the Bay-Delta Water Quality Control Plan prior to approving any change in point of diversion, and the SWRCB cannot use D-1641 and the existing plan as the measure of determining whether the change in point of diversion would unreasonably harm fish and wildlife beneficial uses and public trust resources. We respectfully request that the SWRCB revise its notice and fact sheet to state that the SWRCB shall complete the periodic review of the Bay Delta Water Quality Control Plan before it issues any order authorizing a change in point of diversion, and make clear that the standards for review of whether the change in point of diversion causes unreasonable impacts on fish and wildlife shall not be limited to D-1641 and the existing water quality control plan.

Sincerely,

Doug Obegi
Natural Resources Defense Council

Rachel Zwillinger
Defenders of Wildlife

John McManus
Golden Gate Salmon Association

Tim Sloane
Pacific Coast Federation of Fishermen's Associations

Charles Batts
Friends of San Francisco Estuary

Gary Bobker
The Bay Institute

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regulatory framework for the Delta provided by the WQCP and D-1641.Flows presented by Alternative 4A, beyond those required by D-1641, satisfy the appropriate Delta flow criteria to be considered by the Board under 85086(c)(2)." This is incorrect, as flows under Alternative 4A are likely to lead to continued population declines of longfin smelt, delta smelt, and numerous salmon and steelhead runs, are likely to violate requirements of the state and federal endangered species acts, and are insufficient to achieve the salmon doubling objective of the water quality control plan.

Additional Scientific Information, Recommended Changes to the Bay-Delta Water Quality Control Plan, and Recommendations to Address Scientific Uncertainty and Changing Circumstances

Workshop 1: Ecosystem Changes and the Low Salinity Zone

Prepared by:
Jonathan Rosenfield, Ph.D.
The Bay Institute

Submitted to the State Water Resources Control Board on behalf of:
The Bay Institute
Natural Resources Defense Council
American Rivers
Pacific Coast Federation of Fishermen's Associations

August 17, 2012

Question 1. What additional scientific and technical information should the State Water Board consider to inform potential changes to the Bay-Delta Plan relating to ecosystem changes and the low salinity zone that was not addressed in the 2009 Staff Report and the 2010 Delta Flow Criteria Report? For large reports or documents, what pages or chapters should be considered? What is the level of scientific certainty or uncertainty regarding the foregoing information? What changes to the Bay-Delta Plan should the State Water Board consider based on the above information to address existing circumstances and changing circumstances such as climate change and BDCP?

Response to Question 1: Additional Scientific Information & Recommended Changes to the Bay Delta WQCP

In its 2010 final report on "Development of Flow Criteria for the Sacramento-San Joaquin Delta Ecosystem" (2010 Flow Criteria Report), the State Water Board found that "*the best available science suggests that current flows are insufficient to protect public trust resources.*" The scientific literature and other sources of data that have become available since the 2010 report continue to overwhelmingly and conclusively support this finding.

In addition, several recent studies reinforce the finding that large-scale changes in the Delta's low salinity zone (LSZ) and Delta outflows – changes that are known to be deleterious to numerous native aquatic species and other Public Trust values of the Delta ecosystem – are largely caused and controlled by human activities to divert, export, and store water that are subject to the Board's authority.

Other stressors, such as loss and degradation of physical habitats, water quality impairment, and the effects of introduced species, are a legitimate source of concern regarding their potential contribution to recent and long-term declines in public trust resources, However, the research published in the past few years has tended to either:

(1) reinforce the Board's caution that "… *flow and physical habitat interact in many ways, but they are not interchangeable*." [2010 Flow Criteria Report, p. 1],
(2) question the scientific basis for and/or importance of these other factors, and/or
(3) demonstrate the critical role of freshwater flows in meditating these other stressors.

In short, there is a high and increasing degree of certainty that increased Delta freshwater outflows (relative to available annual runoff) are absolutely necessary (even if not sufficient alone) to protect and restore estuarine habitat and fish and wildlife beneficial uses and public trust resources of the Bay-Delta estuary's low salinity zone. In this written submission, we review and summarize the findings of the new publications, studies, and data and conclude that these new studies and publications support the Board's findings in the 2010 Flow Criteria Report, including:

(1) Existing flows are inadequate to protect Public Trust resources;
(2) Winter/Spring outflows should be substantially increased and should be implemented as a percentage of unimpaired flows occurring in a narrow averaging period;
(3) Fall (and possibly summer) outflows should be increased to provide sufficient habitat following wetter year types; and,

(4) Non-flow measures (such as physical habitat) interact with flow, but are not interchangeable and cannot substitute for flow.

Based on this conclusion and the extensive scientific record on which it rests, and on the fact that the estuarine habitat and fish and wildlife beneficial uses are the most sensitive uses of the Delta's waters, and that these ecological resources are severely imperiled by the current highly degraded condition of the Low Salinity Zone, the Board should analyze the effects of implementing the 2010 Delta outflow criteria as new water quality objectives in the Bay-Delta Plan, make such modifications as may be necessary to avoid or minimize potential unintended consequences to Public Trust resources upstream, and should ultimately adopt outflow objectives that ensure restoration and maintenance of both upstream and downstream Public Trust resources.

The Board should also complement these changes to the Bay-Delta Plan objectives with the adoption and implementation of a clear, transparent, and fully-defined adaptive management strategy that establishes specific, measureable, achievable, relevant and time-bound targets for protection of estuarine habitat, fish and wildlife, and Public Trust values (including but not limited to biocriteria) that the Plan's objectives are intended to achieve; performance monitoring and evaluation protocols to measure whether the objectives are achieving the desired targets; adaptive management triggers for modification of the objectives; and decision pathways that describe how corrective actions will be implemented when necessary. (This recommendation is addressed in our response to the section responding to the Board's second question in the workshop notice).

I. WINTER-SPRING DELTA OUTFLOW AND LOW SALINITY ZONE HABITAT CONDITIONS

A. *New Information Regarding Changes in Delta Outflow Over Time and Causes*

SUMMARY: Central Valley water management activities have caused large-scale changes in the location and size of the LSZ during winter and spring and the magnitude and timing of Delta outflow during this period.

The 2010 Flow Criteria report clearly recognized the effect of human water management activities on flows into, through, and out of the Delta as well as the deleterious effect on ecosystem processes related to these alterations in flow. Taken together with publications and testimony previously entered into the record, publications and data

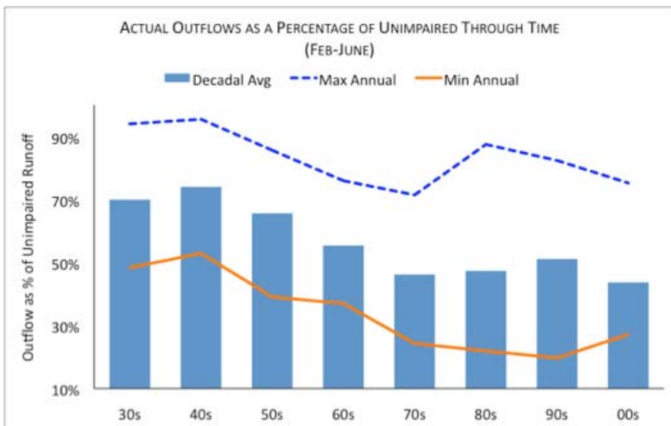

Figure 1: Trends in the mean, minimum, and maximum percentage of unimpaired flow that becomes actual delta outflow, across 8 decades.

developed since 2010 demonstrate unequivocally that winter-spring freshwater flows into, through, and out of the Delta have deteriorated substantially over time (even following promulgation of previous water quality standards) as a result of water diversions throughout the Central Valley (Figure 1).

[San Francisco Estuary Partnership [SFEP]. 2011. The State of San Francisco Bay 2011. Available at: http://sfestuary.org/StateofSFBay2011/][1]

The State of San Francisco Bay Report (SFEP 2011) summarizes the effect of water management on freshwater flows in the upper estuary and the impact of these flow alterations on Public Trust resources in this area. This peer-reviewed report condenses multiple data streams into easy-to-understand metrics that track ecosystem health. The report also analyzes trends in the underlying data that contribute to the synthetic metrics so that readers can understand the root causes of trends in the Bay-Delta's ecological conditions.

SFEP's index of freshwater flows reveals a consistent decline in conditions over time such that a 10-year running average of this indicator has been "poor" since the late 1960's.

SFEP reports:

> *Since 1993, when the San Francisco Estuary Partnership's CCMP called for increasing freshwater availability to the Estuary and restoring healthy estuarine habitat, overall inflow conditions have … generally declined. Similarly, new water quality and flow standards established by the SWRCB in 1995 have not had a detectable effect on the Freshwater Inflow Index.* [p. 23].

and

> *Based on results of the Freshwater Inflow Index, the health of the San Francisco Estuary is critically impaired. Reductions and alterations in freshwater inflow have their greatest impacts in the upstream regions of the Estuary and Suisun and San Pablo Bays where the mix of fresh and salt water creates productive open water estuarine habitat.* [p. 23].

Not surprisingly, given the decline in freshwater flows through the Delta, the extent and quality of low salinity zone habitat declined significantly through time. The report explains:

> *Results of this analysis reveal a steady decline in springtime estuarine open water habitat, from consistently good or fair conditions prior to the 1960s to mostly poor conditions by the 1990s … Conditions improved during the late 1990s, during a sequence of unusually wet years but declined again in the 2000s* [p. 26]

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[1] New scientific publications and studies are highlighted in gray for ease of reference. We have provided online

In appendices, SFEP disaggregates the findings presented in the summary indices. This exercise clearly demonstrates that water diversions from the Central Valley have increased relative to available runoff ("unimpaired flow") in the watershed over time, a pattern that was also revealed in our 2010 submission to the State Board (e.g. TBI et al. #1, Fig. 4). Figure 2 reveals that the percentage of available Central Valley runoff that makes it out of the Delta declines as conditions get drier (to the left of the graph) – diversions from the ecosystem remain relatively constant across hydrological conditions and dry years become disproportionately treacherous for native aquatic species.[2]

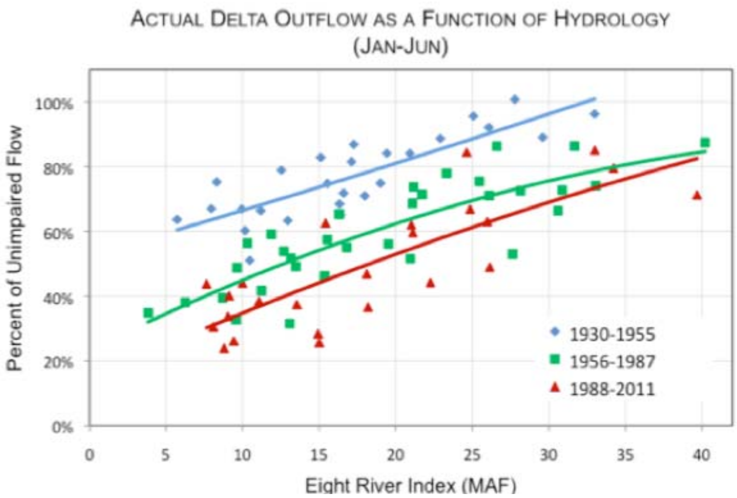

Figure 2: Percentage of available winter-spring runoff in the Central Valley (8-river index) that appears as actual Delta outflow across three time periods. Actual outflow has declined as a fraction of available runoff and has always been lower in drier years than in years with wetter conditions. Modified from SFEP 2011.

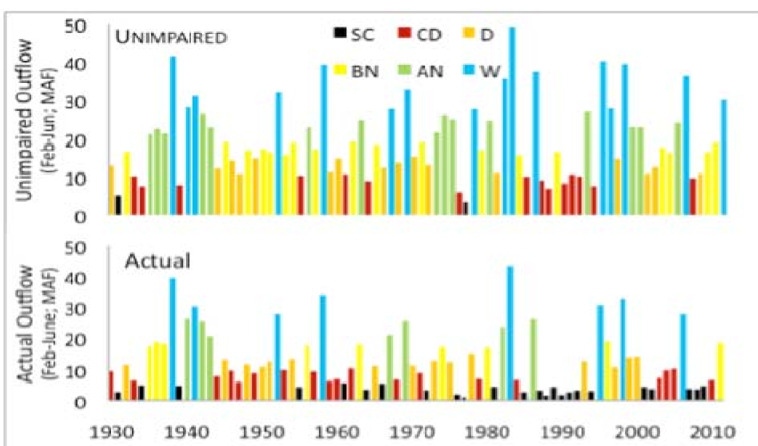

Figure 3: Unimpaired Delta outflow v. Actual Delta outflow through time. Colored bars indicate water year types from "super critical" (black) through "wet" (blue). Diversions result in a chronic drought for the ecosystem. Modified from SFEP 2011.

The result of the increasing water development in the watershed has been a prolonged, severe, and human induced "drought" for the Delta ecosystem (Figure 3). Although natural hydrology in the Central Valley (represented here by "unimpaired flows") is highly variable, the estuary has experienced drought conditions for most of the recent past as a result of water impoundment and diversions. Far from the claim that "we've tried improving flows and it hasn't worked," actual inflows to the Delta have been extremely (super-critically) dry in nearly half (12) of the last 25 years. For comparison, such extremely low Delta outflows occurred naturally only twice in the past 82 years. Wetter conditions ("Above Normal" (green bars) and "Wet" (blue bars) years) have occurred naturally in 10 of the last 25 years (40%) but such benign outflow conditions have materialized in the estuary far less frequently (4 years out of 25). It is no wonder that indicators of low salinity zone conditions, such as populations of pelagic species, have declined to levels associated with a long-term drought.

[2] The Board's 2010 formulation of flows necessary to protect the public trust as a consistent percentage of unimpaired would alleviate the disproportionate impact to the ecosystem of water diversions in drier years.

In addition to reducing the magnitude of ecologically essential freshwater flows through the ecosystem, water storage, diversion and export operations change the timing of those flows dramatically (Figure 4). Because fish and other native organisms have evolved to capitalize on seasonal pulses in flow, the loss of those pulses at the appropriate time, can be devastating to a species' population viability. In particular, by truncating the duration of pulse flows, water export operations cut short the window of time that native species have to complete flow-dependent transitions in their life cycle. Salmon juveniles that historically migrated to the Bay over a multi-month period of elevated flows (e.g. Williams 2006), are now constrained to migrating during regulated "pulse flow" periods that last just a few days or weeks. This has several effects: (1) fish that attempt to migrate outside the pulse-flow window (and the genetic and life history variation they represent) are selected against, which weakens the long-term resilience of the run (Miller et al. 2011) and (2) the entire year class is jeopardized if the fish that do migrate during the pulse window arrive in the bay or ocean at a time when conditions are sub-optimal. Simply put, the life history variation that occurs naturally among native fishes of the Central Valley would only exist if it had produced success (survival and reproduction) with some frequency in the past; eradicating that genetic and life history variation by limiting the duration of key flow conditions jeopardizes the continued existence of native fish populations in the future (Miller et al. 2011; Rosenfield 2010; NMFS 2009; Williams 2006).[3]

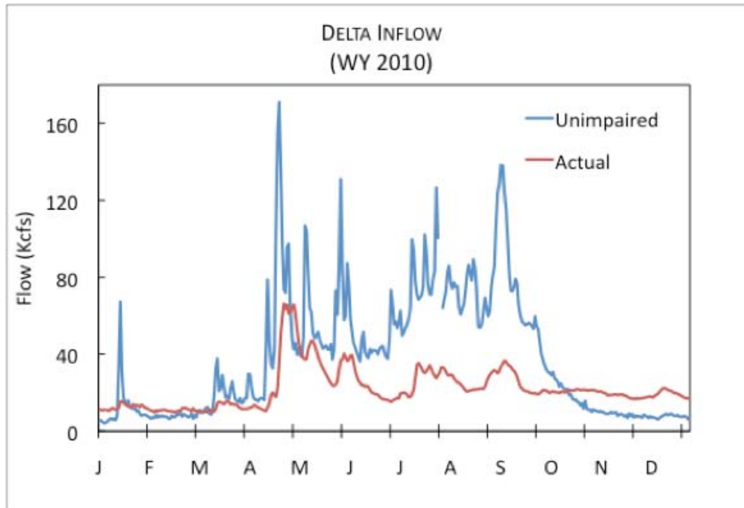

Figure 4: Unimpaired vs. actual inflow Delta hydrographs. Water management activities result in reduced average flows and reduction in flow variation that organisms use to trigger life history transitions. Modified from SFEP 2011.

[Enright, C. and S. Culberson. 2010. Salinity trends, variability, and control in the northern reach of the San Francisco Estuary. San Francisco Estuary and Watershed Science, 7(2). Available at: http://escholarship.org/uc/item/0d52737t].

Studying long-term data to determine which drivers influence Delta outflow and salinity at various locations in the Delta and Suisun Marsh, Enright and Culberson (2010) concluded that the State and federal water projects influence the trends in outflow and salinity across years and in specific months. This analysis reveals that, despite an almost 10% increase in rainfall measured in the Central Valley during the post-water project period, annual Delta outflow has decreased and salinity has increased at locations throughout the northern part of the San Francisco Estuary. These findings reinforce previous conclusions (referenced here and in previous testimony) that operations of the State and federal water projects exert a major

[3] The Board's 2010 recommendation that freshwater flows to protect the public trust ought to reflect percentage of unimpaired based on a narrow time window, such as a 14-day running average, would go a long way to restoring the natural hydrographic patterns in timing and pattern of freshwater flow.

influence on the size, position, and seasonal patterns of the estuary's low salinity zone, and that the operations of the State and federal water projects has made the upper reaches of the estuary more saline, not fresher (as is commonly asserted). Figure 5 (Enright and Culberson 2010's Figure 5) shows different resolutions of long-term trends in precipitation (hydrological conditions), actual Delta outflow, and salinity (environmental conditions), with the right panel revealing the long-term trend after accounting for seasonal (left column) and decadal (center column) patterns – the vertical dashed line divides the pre- and post-project periods. Enright and Culberson (2010) conclude, in part:

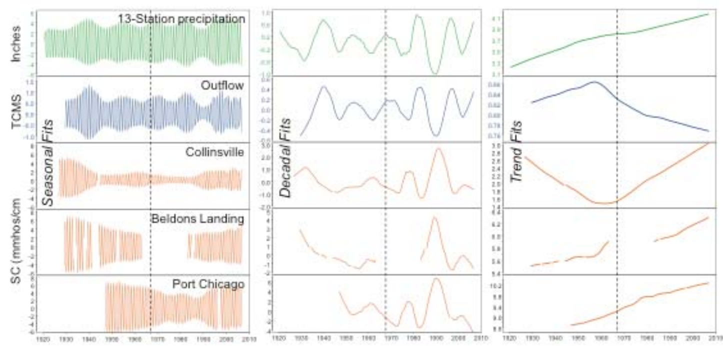

Figure 5: Variation in rainfall, Delta outflow, and salinity in the northern SF Estuary at three different temporal resolutions. At a decadal scale (right column) increasing precipitation, decreasing Delta outflow, and increasing salinity trends are apparent. [Enright and Culberson 2010, Figure 5].

> *The state and federal water projects decoupled long-term trends in annual mean outflow and salinity from long-term trends in precipitation.*

and

> *The water projects dampen seasonal and annual outflow and salinity variability.* [p. 10].

B. *New Scientific Information Regarding Effects of Outflow on Fish Populations and Lower Trophic Levels*

SUMMARY: Changes in Delta outflow during the winter-spring are closely linked to population dynamics of numerous Public Trust resources -- less outflow corresponds to fewer aquatic organisms.

As the Board recognized in the 2010 Flow Criteria Report, freshwater flows out of the Delta in the winter and spring are strongly (orders of magnitude), significantly, and persistently (over many decades) correlated with populations of pelagic fish and other aquatic organisms in the Bay-Delta Estuary. The scientific evidence is simply overwhelming that freshwater flows control one or many physical, chemical, and biological processes that directly influence abundance and distribution patterns of many native species in the Bay-Delta. As a result, almost all scientists working on the Bay-Delta estuary subscribe to this view. As SFEP (2011; cited above) notes:

> *Scientists now consider poor freshwater inflow conditions to be one of the major causes for the ongoing declines of fish populations observed in the upper Estuary* [p.23].

[National Research Council. 2012. Sustainable water and environmental management in the California Bay-Delta. National Research Council. The National Academies Press, Washington, DC. Available at: https://download.nap.edu/catalog.php?record_id=13394]

The National Research Council's report on sustainable water and environmental management in the Bay-Delta found that evidence strongly supported a dominant role of winter-spring Delta outflows in driving population dynamics of native pelagic species. The NRC panel wrote:

> *Given that the position of X_2 for different periods of time appears to be important for different species, one can argue that water operations should be designed to preserve as much of both the volume of outflow and timing of that volume that would be observed in the absence of diversions (Moyle et al. 2010, SWRCB 2010). In light of the nature of the connection between flow and the position of X_2, this may necessitate limiting available water supply, especially in dry years.* [NRC 2012:63]

In addition, the panel concluded that:

> *… it appears that if the goal is to sustain an ecosystem that resembles the one that appeared to be functional up to the 1986-93 drought, exports of all types will necessarily need to be limited in dry years, to some fraction of unimpaired flows that remains to be determined. Setting this level, as well as flow constraints for wetter years, is well beyond the charge of this committee and accordingly we suggest that this is best done by the SWRCB, which is charged with protecting both water rights holders and the public trust.* [NRC 2012: 105]

1. New Scientific Information Regarding Effects of Outflow on Longfin Smelt

The Board's findings in the 2010 Flow Criteria Report were based in part on our work to identify the fresh water flow needs of individual species' life stages as they related to particular attributes of population viability – abundance, spatial distribution, life history diversity, and productivity (TBI et al. 2010 Exhibits 1-4; McElhany et al. 2000). With particular regard to the low salinity zone, we presented substantial new analyses of the population response of longfin smelt (*Spirhinchus thaleichthys*) to levels of Delta outflow during the winter and spring and demonstrated that flows that would be sufficient to restore longfin smelt populations in this estuary would also be protective of other aquatic organisms in the pelagic (open water) areas downstream of the Delta.

New publications, data, and analyses of the estuary's longfin smelt population strongly support the conclusions and recommendations of our 2010 analysis (TBI et al. 2010 exhibit #2). Indeed, the case for improving winter-spring Delta outflows (or, equivalently, locating X_2 further downstream) in order to protect and restore longfin smelt populations has been bolstered in the past two years.

[Thomson, J.R., W.J. Kimmerer, L.R. Brown, K.B. Newman, R. Mac Nally, W.A. Bennett, F. Feyrer, and E. Fleishman. Bayesian change point analysis of abundance trends for pelagic fishes in the Upper San Francisco Estuary. Ecological Applications 20:1431-1448. Available at: http://online.sfsu.edu/~modelds/Files/References/ThomsonEtal2010EcoApps.pdf]

This study used Bayesian and linear regression models to examine trends in abundance of four pelagic fish species (delta smelt, longfin smelt, striped bass, and threadfin shad) and identify the biotic or abiotic covariates most closely associated with the trends in abundance. The multispecies model identified step changes in abundance for 3 of the 4 species in the early 2000s and concluded that the decline of longfin smelt was a continuation of a longer-term decline. For longfin smelt, the individual species model identified the decline in abundance as responses to increases in spring X2 (reductions in spring outflow). The authors concluded, in part:

> *"… at the estuary scale, abiotic factors (water clarity, X2, exports) may have more influence on interannual variation in abundances of the four species than do biotic variables."* [p. 1445].

Acknowledging that their results reinforced previous evidence regarding the likely causes of pelagic species population declines in this ecosystem, Thomson et al wrote:

> *"The covariates we identified as strongly associated with pelagic fish abundance, namely X2, water clarity, and export flows, previously have been hypothesized to affect abundance."* [p. 1443].

[Mac Nally, R., J.R. Thomson, W.J. Kimmerer, F. Feyrer, K.B. Newman, A. SIH, W.A. Bennett, L. Brown, E. Fleishman, S.D. Culberson, and G. Castillo. 2010. Analysis of pelagic species decline in the upper San Francisco Estuary using multivariate autoregressive modeling (MAR). Ecological Applications 20:1417-1430. Available at: http://online.sfsu.edu/~modelds/Files/References/MacNallyetal2010EcoApps.pdf]

This study utilized multivariate autoregressive modeling to analyze what factors were contributing to the declines of four pelagic fish species (delta smelt, longfin smelt, striped bass, and threadfin shad). The authors studied 54 covariates, including water exports, spring and fall X_2, prey abundance, predator abundance, and water temperatures. They concluded:

> *The position of* [X_2] *(a measure of the physical response of the estuary to freshwater flow) and increased water clarity over the period of analyses were two factors affecting multiple declining taxa (including fishes and the fishes' main zooplankton prey).* [pp. 1417]

High summer water temperatures, spring water exports, abundance of largemouth bass, abundance of summer calanoid copepods, and winter water exports were negatively associated with delta smelt abundance to some degree. The modeled covariates explained 51% of the variability in abundance, and the authors concluded that water exports and X2 are associated with the declines and can be managed.

[Rosenfield, J.A. 2010. Conceptual life-history model for longfin smelt (*Spirinchus thaleichthys*) in the San Francisco Estuary. California Department of Fish and Game, Sacramento, CA. http://www.dfg.ca.gov/ERP/conceptual_models.asp].

The CALFED Ecosystem Restoration Program initiated an effort to screen and evaluate potential restoration actions in the Delta, known as the Delta Regional Ecosystem Restoration Implementation Program (DRERIP). One part of that evaluation program involved the creation of conceptual models that summarized the state of knowledge regarding species' life histories, ecosystem processes, habitats, and stressors. Final versions of these models are now published and available through CDFG and should be incorporated into the Board's record in these proceedings.

One of these DRERIP models focuses on what is known about the life history of longfin smelt and the magnitude and scientific certainty surrounding the impact of different stressors on the species' life history and ecology. This conceptual model clearly emphasizes the wealth of research demonstrating the high magnitude effect of freshwater flow on longfin smelt population abundance – the relationship between winter-spring Delta outflow and success of longfin smelt eggs, larvae, and juveniles is rated as "high" as is the scientific certainty of that impact. Fresh water outflow and salinity (which is directly modified by fresh water outflow) are the only two stressors identified as having both high magnitude impacts on longfin smelt survival and a high certainty of impact (Rosenfield 2010; Table 3 – "stressor matrix"). Of particular relevance are the figures that depict the likelihood and magnitude of impact of different stressors on the probability that longfin smelt will transition from one lifestage to the next (Rosenfield 2010; Figures 3-5, pp. 34-36). These schematic diagrams clearly identify Delta freshwater outflow as an ecosystem process with both high magnitude and high certainty effects on numerous stressors of longfin smelt populations – in every case, increased freshwater flow results in stressor reduction.

Furthermore, the model describes how Delta outflow affects the spatial distribution of spawning adult and larval longfin smelt. This mechanism largely determines longfin smelt entrainment rates at the South Delta pumps as lower winter-spring Delta outflows position longfin smelt nearer to the pumps and typically result in much higher entrainment rates than higher outflow conditions that help distribute longfin smelt further to the west.

US Fish and Wildlife Service. 2012. Endangered and Threatened Wildlife and Plants; 12-month Finding on a Petition to List the San Francisco Bay-Delta Population of the Longfin Smelt as Endangered or Threatened. 50 CFR Part 17. [Docket No. FWS-R8-ES-2008-0045]. Available at: http://www.fws.gov/cno/es/speciesinformation/Longfin%20Smelt%2012%20month%20finding.pdf

In 2012, The US Fish and Wildlife Service (FWS) issued a 12-month finding in response to a petition to list the San Francisco Bay-Delta population of longfin smelt under the federal Endangered Species Act (ESA; this population is already listed as a threatened species under the state ESA). The FWS determined that this population of longfin smelt warranted listing as a threatened species, though administrative priorities precluded formal listing at this time.

While describing the threats to this species in the Bay-Delta, FWS wrote:

> *In the Bay-Delta estuary, increased Delta outflow during the winter and spring is the largest factor positively affecting longfin smelt abundance … During high outflow periods, larvae presumably benefit from increased transport and dispersal downstream, increased food production, reduced predation through increased turbidity, and reduced loss to entrainment due to a westward shift in the boundary of spawning habitat and strong downstream transport of larvae (CFDG 1992; Hieb and Baxter 1993; CDFG 2009a). Conversely, during low outflow periods, negative effects of reduced transport and dispersal, reduced turbidity, and potentially increased loss of larvae to predation and increased loss at the export facilities result in lower young-of-the-year recruitment.* [p. 38].

The 12-month finding goes on to describe the effect of freshwater flow on longfin smelt populations and, in particular, the effect of water diversions on longfin smelt success. For example, the finding states:

> *Because longfin smelt spawn in freshwater, they must migrate farther upstream to spawn as flow reductions alter the position of X_2 and the low-salinity zone moves upstream. Longer migration distances into the Bay-Delta make longfin smelt more susceptible to entrainment in the State and Federal water pumps (see Factor E: Entrainment Losses). In periods with greater freshwater flow into the Delta, X_2 is pushed farther downstream (seaward); in periods with low flows, X_2 is positioned farther landward (upstream) in the estuary and into the Delta. Not only is longfin smelt abundance in the Bay-Delta strongly correlated with Delta inflow and X_2, but the spatial distribution of longfin smelt larvae is also strongly associated with X_2. As longfin hatch into larvae, they move from the areas where they are spawned and orient themselves just downstream of X_2. Larval (winter-spring) habitat varies with outflow and with the location of X_2, and has been reduced since the 1990s due to a general upstream shift in the location of X_2. The amount of rearing habitat (salinity between 0.1 and 18 ppt) is also presumed to vary with the location of X_2. However, as previously stated, the location of X_2 is of particular importance to the distribution of newly-hatched larvae and spawning adults. The influence of water project operations from November through April, when spawning adults and newly-hatched larvae are oriented to X_2, is greater in drier years than in wetter years.* [p. 39]

The FWS finding obviously indicates that the continued existence of this unique and ecologically important species in the Bay-Delta ecosystem is threatened. By not listing this longfin smelt population, FWS left it uncovered by the protections afforded threatened and endangered species under the federal ESA, even though those protections are warranted. What is more, the most recent reviews of the latest draft Bay Delta Conservation Plan (BDCP), which is supposed to contribute to the recovery of longfin and other native fish species, indicate that the BDCP as currently envisioned will have a substantial negative impact on this species (*see below*). Thus, actions to protect the Bay-Delta's longfin smelt population (and the estuarine habitat on which it and numerous other pelagic species rely) are all the more imperative – new outflow and other objectives promulgated by the Board may be the last best hope for conserving what was formerly among the most abundant fish in the Bay-Delta.

[BDCP "Red Flag" Documents [California Department of Fish and Game; US Fish and Wildlife Service; and National Marine Fisheries Service. April 2012 BDCP EA (Ch. 5) Staff "Red Flag" Review Comprehensive List. Available at: http://baydeltaconservationplan.com/Libraries/Dynamic_Document_Library/Effects_Analysis_-_Fish_Agency_Red_Flag_Comments_and_Responses_4-25-12.sflb.ashx]

In February 2012, BDCP released a draft Effects Analysis of a project proposal that was designed to minimize the direct impacts of water export operations (e.g. entrainment, stranding), but was projected to increase water diversions over recent norms. The fish and wildlife trustee agencies were asked to comment on the proposed project and Effects Analysis. These preliminary reviews, known collectively as the "Red Flag Staff Reviews," were highly critical of the draft BDCP (both the Plan itself and its Effects Analysis – see below for complete discussion). In particular, the agencies expressed grave concerns about the effect of anticipated reductions in Delta outflow arising from State and federal water project operations described in the Draft plan. The FWS wrote:

> *The Low Salinity Zone (LSZ) is the primary habitat for delta smelt and the primary rearing habitat for larval longfin smelt and juvenile to adult splittail. The Preliminary Proposal modeling indicates that Delta outflows during February-June will more frequently be near the minima required by the SWRCB under D-1641. This will represent a substantial negative project effect on longfin smelt. The effects analysis and Net Effects only partly address this issue, reporting that Preliminary Project is expected to provide a large, positive impact to food resources that will offset the negative impact to "transport flows". But there are multiple mechanisms by which Delta outflow can affect longfin smelt recruitment; transport flow is only one of them. Transport flows might be managed via gates or other engineering solutions. The other mechanisms for which there is stronger scientific support are kinetic energy mechanisms (low-salinity zone habitat area and retention from gravitational circulation in the estuary). The problems that reduced outflow creates by changing these processes do not have reasonable engineering solutions, and at present appear to be manageable only via outflow* [pp. 12-13].

2. New Scientific Information Regarding the Effects of Outflow on Other Fish Species

The longfin smelt is not the only native fish species in the Bay-Delta Estuary whose population responds strongly to Delta outflows in the winter-spring period. The populations of several other species also display long-term, statistically significant, and high-order relationships with winter-spring Delta outflows (or X_2; e.g., Jassby et al. 1995; Kimmerer 2002; Kimmerer et al 2009; TBI et al. 2010, Exhibit #2). In 2010 and 2011, these species responded to hydrological conditions exactly as one would expect given their life histories and their well-established historical response to freshwater flow variations.

[Population Response in Water Years 2010 & 2011 – data from CDFG. Available at: http://www.dfg.ca.gov/delta/data/].

Water years 2010 and 2011 were wetter than the three years leading up to publication of the 2010 Flow Criteria Report (Figure 6). In combination with high flows, operational constraints required under biological opinions for Delta smelt and anadromous species maintained more favorable in-Delta hydrodynamic conditions (e.g. less net negative flow from Old and Middle River) for a longer period than has occurred recently. These protective regulations notwithstanding and despite the fact that WY 2011 was only in the top ~80 percent of years in terms of available runoff (i.e., WY 2011 was wet, but not extremely wet), water exports from the South Delta reached an all-time high.

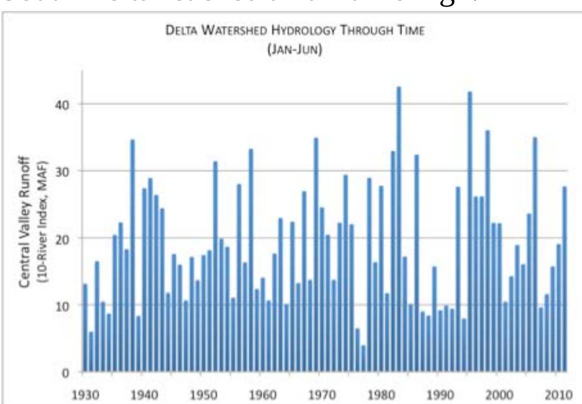

Figure 6: Central Valley Hydrology through Time

Native fish populations responded positively to improved Delta outflows and Delta hydrodynamic conditions (Figure 7) – not surprisingly given the long-term, significant, high magnitude, and widespread response of the Delta ecosystem to increased Delta inflow, through-flow, and outflow (e.g. Stevens and Miller 1983; Jassby et al. 1995; Kimmerer 2002; Kimmerer et al. 2009). Water years 2010 and 2011 illustrate the point made by almost 5 decades of fish and flow data from this estuary: increased freshwater flow into, through, and

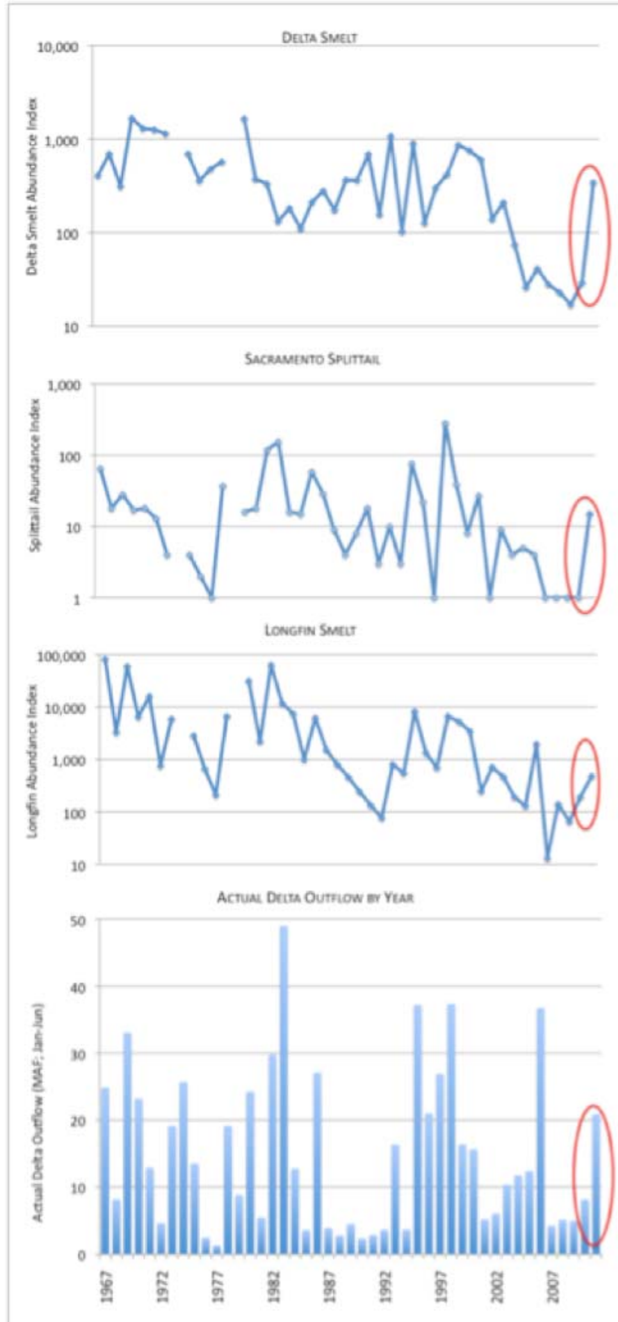

Figure 7: Response of three pelagic fish species to variation in winter-spring Delta outflow. Ovals highlight population and outflow increases in the 2 years since the State Board issued its 2010 Flow Criteria Report.

out of the Delta generally leads to increased abundance of native fishes. Although 2011 is only one year (albeit, one with a pattern very similar to that seen in "wet" years throughout the ~45 year fish population sampling record), the population responses of organisms as ecologically diverse as Delta smelt, longfin smelt, striped bass, Sacramento splittail should be somewhat independent of one another, unless one assumes that each of these populations is affected by the same drivers – drivers like freshwater flow. It is worth noting that the moderate population increases seen in 2010 and the more dramatic response in 2011 could not have been a response to restoration of shallow water habitat; reduction in ammonium discharge from the Sacramento Municipal Wastewater Treatment facility: or reduction in the abundance or extent of fish predators – none of those other stressors changed substantially in 2010 and 2011. Similarly, mortality due to entrainment at the South Delta water export facilities was relatively high in 2011 for some species; nearly 9,000,000 Sacramento splittail and 27,000 Sacramento sucker were "salvaged" at the south Delta export pumps (a record for each of these endemic fish species) and over 200 white sturgeon where captured at the pumps, their worst year since 1998 (TBI 2012). The only change in major ecosystem drivers that improved in 2011 compared to the previous 4-years was the volume of water that flowed into, through, and out of the San Joaquin Delta during the winter and spring and the improvement in fall habitat conditions.

3. New Scientific Information Regarding the Effects of Outflow on Lower Trophic Levels and Food Webs

In addition to fish species, the 2010 Flow Criteria Report recognized that Delta freshwater outflow significantly affects populations of numerous invertebrate species that form the base of the food web for fish and other species (*see also* Kimmerer 2002; Kimmerer et al. 2009). Freshwater flow, through its myriad effects on the Low Salinity Zone, structures and controls the distribution of aquatic species assemblages in the upper reaches of the estuary and beyond. Recent scientific studies and publications confirm the validity of this finding (e.g. Mac Nally et al. 2010; NRC 2012; Peterson and Vayssieres 2010; Winder and Jassby 2010)

For instance, the analysis by Mac Nally et al (2010) found a strong relationship between X_2 and the abundance of both calanoid copepods and mysids (both of which are part of the food web for delta smelt, longfin smelt, and other native fish species). When X_2 is more seaward in the spring (lower X_2 values), the spring abundance of copepods and mysids is greater, "*which also would propagate back through those food pathways*" to delta smelt and longfin smelt (Mac Nally 2010:1426). Because "*Longfin smelt abundances had strong negative correlations with calanoids in spring and summer and mysids in spring*," and Delta smelt abundance had a weaker relationship with calanoid abundance in summer, the authors concluded that X_2 "*seems to have a profound effect on the declining fish and on their prey*," (Mac Nally 2010:1428).

The National Research Council (NRC 2012) reviewed the effects of X_2 on aquatic resources, including food webs. They reviewed work by Jassby that found that X_2 affected "*the abundance/biomass of a number of organisms, including the total production of particulate organic carbon by phytoplankton in Suisun Bay, the shrimps Neomysis mercedis and Crangon franciscorum, and several fishes*," (NRC 2012:58, citing Jassby 1995). They reviewed the Mac Nally et al. 2010 study, stating that it found that, "*The position of* X_2 *in the spring ("spring* X_2*")*

[s]trongly influences the abundance of mysids, longfin smelt, and calanoid copepods." (NRC 2012:60). After reviewing work by Jassby, Kimmerer, and Mac Nally, the NRC report concluded that:

> *Thus, while the mechanisms behind the influence the of position of X_2 on the abundance of a variety of biota remain hypothetical, the statistical relations reported in several papers show that abundance of a number of species at different trophic levels found in the Delta and San Francisco Bay is higher when X_2 is farther downstream. This implies that sufficient reductions in outflow due to diversions would tend to reduce the abundance of these organisms.* [p. 60].

The National Research Council's report also included an appendix prepared by Dr. Wim Kimmerer, which discussed changes in zooplankton composition and abundance over time. The appendix notes that:

> *Opportunities to reverse the declines in zooplankton are severely limited, at least with our current knowledge of their ecology. Producing more food for them is impracticable because adding more phytoplankton to the system would probably just produce more clams. There may be opportunities to enhance populations of some zooplankton through manipulations of freshwater flow, and control of nutrient inputs to the Delta may improve growth conditions for phytoplankton and reduce the frequency of harmful algal blooms. These are active areas of research which will help to clarify the potential responses to these changes.* [NRC 2012:201].

Several other studies provide additional information on the relationship between outflow and lower trophic levels.

[Winder, M. & A.D. Jassby. 2010. Shifts in zooplankton community structure: implications for food-web processes in the upper San Francisco Estuary. Estuar. Coasts. Available at: http://www.springerlink.com/content/b30544u2xx0l235u/fulltext.pdf]

This paper reported analysis of long-term patterns in zooplankton abundance, distribution, and species composition in the Bay-Delta estuary. They note the correspondence between major changes in the estuary's zooplankton assemblage and native fish populations that occurred during the 1987-1993 drought, but found no evidence that more recent declines in fish populations (i.e. the POD) were caused by changes in zooplankton abundance. They wrote:

> *While the long-term decline of diverse fish populations in the upper SF Estuary coincided with reduced primary and secondary production (Cloern 2007), our analysis showed that the sudden drop of many pelagic fishes in 2002 (Sommer et al. 2007; Thomson et al. 2010) was not accompanied by an equivalent decrease in the quantity of zooplankton carbon. Substantial zooplankton and mysid declines occurred in the mid- to late 1980s, and biomass of both groups remained at low levels thereafter, without significant changes in the early 2000s when pelagic fish densities dropped substantially (Table 2). This suggests that changing prey*

> *quantity was not a dominant factor contributing to the recent fish declines.* [Winder & Jassby 2010:686-87]

[Peterson, H. and Vayssieres, M. 2010. Benthic Assemblage Variability in the Upper San Francisco Estuary: A 27-Year Retrospective. San Francisco Estuary and Watershed Science, 8(1). Available at: http://escholarship.org/uc/item/4d0616c6]

Peterson and Vayssieres (2010) studied 27 years of data on benthic assemblages along the major axis of the northern estuary and concluded:

> *Hydrologic variability was associated with significant changes in benthic assemblage composition at all locations. Benthic assemblage composition was more sensitive to mean annual salinity than other local physical conditions. That is, benthic assemblages were not geographically static, but shifted with salinity, moving down-estuary in years with high delta outflow, and up-estuary during years with low delta outflow, without strong fidelity to physical habitat attributes such as substrate composition or location in embayment vs. channel habitat.* [p. 1].

As a result, the authors found that species assemblages at specific geographic locations such as Grizzly Bay varied dramatically between high outflow and low outflow years. (Peterson & Vayssieres 2010:19-20).

4. <u>New Scientific Information Regarding Relationships Between Outflow and "Other Stressors"</u>

SUMMARY: New scientific information casts further doubt upon the hypothesized connection between certain "other [non-flow] stressors" and decline of native fish species asserted in 2010.

During the Board's Delta Flow Criteria proceedings in 2010, several parties promoted the hypothesis that factors other than fresh water flows were driving declines in populations of public trust species. Many of these putative stressors involved different mechanisms for suppressing the pelagic food web in the Bay-Delta. However, none of the arguments presented in support of this hypothesis provided any basis for making a direct connection between the hypothesized cause of a decline in primary productivity and the fish populations that were alleged to be affected by this decline. Most of these species are secondary consumers, that is, they feed two levels away from phytoplankton in the food web. Although it is intuitively attractive to argue that a decline in production at the base of the food web would lead to a decline in production of secondary consumers (or, in some cases, predatory fish), this kind of linkage has not been demonstrated in this system (e.g. Kimmerer 2002). Indeed, with regard to trophic interactions, Thomson et al. (2010; cited below) found:

> *"…the strongest effects generally were ''top-down,'' with fish apparently having more influence on prey biomass than vice versa"*. [p. 1445].

i. New Scientific Information Regarding the Effects of Ammonium Loadings

[Cloern, J.E, A.D. Jassby, J. Carstensen, W.A. Bennett, W. Kimmerer,, R. Mac Nally, D.H. Schoellhamer, M. Winder. 2012. Perils of correlating CUSUM-transformed variables to infer ecological relationships (Breton et al. 2006; Glibert 2010). Limnol. Oceanogr., 57:665–668. Available at: http://kjiwuqx.aslo.org/lo/toc/vol_57/issue_2/0665.pdf]

and by reference

[Glibert, P. 2010. Long-term changes in nutrient loading and stoichiometry and their relationships with changes in the food web and dominant pelagic fish species in the San Francisco Estuary, California. Rev. Fish. Sci. 18: 211–232. Available at: http://sustainabledelta.com/pdf/GlibertReviewsFisheriesScience.pdf]

During the State Water Board's 2010 Delta Flow proceedings, a manuscript by Glibert (2010) was offered as evidence to suggest that ammonium loadings, through their putative effect on the pelagic food web, were driving declines in the fish fauna of the Sacramento Estuary and that freshwater flows were relatively unimportant. Although we do not dispute the potential value of addressing ammonium inputs (or other potential toxins) to the estuary, the analysis by Cloern et al. (2012) demonstrates that the correlations between ammonium and fish populations reported by Glibert (2010) were artifacts of an unwarranted and invalid statistical technique.

Cloern et al. 2012 explored and invalidated the statistical approach employed by Glibert (2010) and the conclusions Glibert posited regarding ecosystem processes in this San Francisco Estuary. Specifically, Glibert (2010) presented an unorthodox statistical analysis that led her to conclude that recent zooplankton and fish species declines were driven by a single factor, increased ammonium inputs from the effluent of municipal wastewater treatment plants. Cloern et al (including eight of the most respected and experienced ecological researchers who have studied the San Francisco Estuary) found:

> "*…no history for regression (or correlation) analyses on CUSUM-transformed variables prior to its use by Breton et al. (2006), and we have found no theoretical development or justification for the approach. We prove here that the CUSUM transformation, as used by … Glibert (2010), violates the assumptions underlying regression techniques. As a result, high correlations may appear where none are present in the untransformed data… Regression analysis on CUSUM-transformed variables [the method used by Glibert 2010] is, therefore, not a sound basis for making inferences about the drivers of ecological variability measured in monitoring programs.* [Emphasis added] [p. 665]

Cloern et al (2012) conclude:

> "*… Glibert (2010) inferred a strong negative association between delta smelt abundance and wastewater ammonium from regression of CUSUM transformed time series. However, the Pearson correlation (r = -0.096) between the time*

series … is not significant, even under the naive … assumptions (p = 0.68). In short, correlations between CUSUM-transformed variables should not be used as a substitute for analysis of the original untransformed variables." [Emphasis added] [p. 668]

ii. New Scientific Information Regarding the Effects of Invasive Benthic Grazers

Peterson and Vayssieres (2010; cited above) discounted the potential linkage between putative stressors such as benthic grazing (e.g. clams), pesticides, or microcystines from toxic algal blooms and the recent pelagic organism decline (POD). For example, they found:

- *"*[Benthic] *assemblage structure during the POD years was not significantly different from other post-invasion years at any of the stations,"*
- *"…no evidence from the benthic abundance data that the influence of benthic grazing underwent a significant change coincident with the POD,"*
- *"…no decline in amphipod species (… important prey for pelagic fish) was evident during the POD …"* [and thus that] *"…the role of pesticides in the POD may be limited,"* and
- *"… that microcystines probably did not have a broad effect in the upper estuary"*. [p: 22]

Winder and Jassby (2010; cited above) reported analysis of long-term patterns in zooplankton abundance, distribution, and species composition in the Bay-Delta estuary. They note the correspondence between major changes in the estuary's zooplankton assemblage and native fish populations that occurred during the 1987-1993 drought, but found no evidence that more recent declines in fish populations (i.e. the POD) were caused by changes in zooplankton abundance. They wrote:

While the long-term decline of diverse fish populations in the upper SF Estuary coincided with reduced primary and secondary production (Cloern 2007), our analysis showed that the sudden drop of many pelagic fishes in 2002 (Sommer et al. 2007; Thomson et al. 2010) was not accompanied by an equivalent decrease in the quantity of zooplankton carbon. Substantial zooplankton and mysid declines occurred in the mid- to late 1980s, and biomass of both groups remained at low levels thereafter, without significant changes in the early 2000s when pelagic fish densities dropped substantially (Table 2). This suggests that changing prey quantity was not a dominant factor contributing to the recent fish declines. [pp. 686-687]

In addition, new scientific information regarding effects of fall outflow on *Corbula amurensis* and other invasive benthic species is discussed *infra*.

iii. New Scientific Information on the Relationship Between Physical Habitat and Flow

In the 2010 Flow Criteria Report, the Board correctly noted that "…*flow and physical habitat interact in many ways, but they are not interchangeable*." Put another way, increased flows of fresh water into, through, and out of the Delta, at appropriate times of year (particularly, the winter and spring) are absolutely necessary, if not sufficient on their own, to restore the public trust values and protect beneficial uses of the Bay-Delta ecosystem.

In its review and revision of the Bay-Delta Plan, the Board has indicated that it anticipates using relevant information from the environmental documentation being prepared on the effects of the proposed Bay Delta Conservation Plan (BDCP). A central assumption of the BDCP to date has been that negative impacts of increased Delta exports by the state and federal water projects can be offset by restoring tens of thousands of acres of shallow tidal and floodplain habitats in the Delta. This assumption, and the failure to adequately analyze it in the environmental documents thus far, has been widely criticized by the scientific community. All of the federal and state fish and wildlife trustee agencies as well as various independent scientific review panels have commented repeatedly that the BDCP's projected impact on freshwater flow conditions as a result of increasing exports will be deleterious to native fish species (regardless of the fact that the new diversion would be equipped with improved fish screening technology that would presumably reduce the direct impact of entrainment at the new diversion) and that its plan to mitigate these impacts by improving habitat conditions are speculative at best. Below, we describe the feedback on recent versions of the BDCP as it is relevant to current arguments about the magnitude and likelihood of potential non-flow related solutions to the decline in the Bay-Delta's public trust resources.

[Parker, A., Simenstad, S., George, T., Monsen, N., Parker, T., Ruggerone, G., and Skalski, J. 2012. Bay Delta Conservation Plan (BDCP) Effects Analysis Phase 2 Partial Review, Review Panel Summary Report. Delta Science Program. Available at: http://deltacouncil.ca.gov/sites/default/files/documents/files/BDCP_Effects_Analysis_Review_Panel_Final_Report_061112.pdf]

This independent scientific peer review of the BDCP Effects Analysis was highly critical of the Plan's analysis of food webs, habitat restoration, and effects on phytoplankton production, concluding that, "*the BDCP treats restoration as a 'given' positive, without considering to much extent that the same actions will also 'create' habitat for trophic consumers (e.g., Egeria invading and providing habitat for predators of threatened fish), or trophic competitors (e.g., filter-feeling clams creating permanent phytoplankton sinks)*" and stating further that, "*the treatment of food resource availability is grossly incomplete and overly simplistic*" (Parker 2012: 22, 27).

The panel found that restored tidal marsh habitat could lead to increased Submerged Aquatic Vegetation and introduced species, and that the BDCP's Effects Analysis failed to consider the potential that:

> *…these shallow open water habitats will be new habitat for expansion of invasive clams such as Corbicula. Under this scenario, the new shallow water habitats would likely act as net sinks for pelagic phytoplankton, and not sources of phytoplankton, thus acting as a net negative effect for food resource availability.* [p. 28]

In addition, the authors found that restored tidal marsh habitat could lead to eutrophication, harmful algal blooms, or low dissolved oxygen, and that "[*t]his would most likely occur in shallow open water habitats with poor flushing / long residence times, i.e., the type of habitats being proposed under the BDCP*," (Parker et al. 2012:28). The peer review also noted that currently:

> *…some of the shallow open water habitats (i.e., Mildred Island) with long residence time are habitat for cyanobacteria, including Microcystis spp. While specific drivers of Microcystis blooms are still not resolved (but see Lehman 2005; Lehman et al. 2008), water temperature and residence time have been implicated. Under future climate scenarios, shallow open water habitats may promote Microcystis and other harmful cyanobacteria species (e.g. Anabaena, Aphanizomenon).* [pp. 28-29]

Finally, the authors specifically looked at the potential impacts to longfin smelt from BDCP proposals that would include habitat restoration but reduce winter/spring outflow. The peer review strongly recommended that BDCP must avoid further declines in the longfin smelt population "*while waiting for possible beneficial effects of habitat restoration*," noting that habitat restoration would take years to be accomplished and that "*the benefits of habitat restoration for longfin smelt are not highly certain*." (Parker 2012:39-40)

The BDCP Red Flag Staff Reviews (2012; cited above) were extremely critical of the assumption that habitat restoration elements of the Plan would more than mitigate for the project's increased water exports. For example, regarding the impacts of reduced flows resulting from BDCP on sturgeon, CDFG found:

> *The collective predicted negative river flow effects of the [Project]create the risk of a depressive effect on sturgeon production that may not be overcome by more favorable… aspects (e.g. reduced entrainment, increased food production supply). This suggests the need to modify the [Project] to reduce the magnitude and frequency of river flow reduction occurrences, in both upstream and downstream areas.* [p. 2]

Regarding the impacts of reduced flows resulting from BDCP on ecosystem processes in the low salinity zone, FWS found:

> *Reduction of flows (in full consideration of timing, magnitude, variability) is the most fundamental cause of stress and driver of change to the fishes and food web that have adapted to the tidal and freshwater mixing environment that is the Bay-Delta ecosystem. In addition, some of the other stressors listed and assumed to be*

> *addressed through the* [BDCP] *conservation measures are either directly or indirectly influenced by Delta inflows, exports, and outflows.* [p. 11].

and

> *Increased residence times and reduced flushing of the Delta by Sacramento River water appear likely to result in interior-Delta channels that are further dominated by agricultural runoff, invasive aquatic vegetation, warmer temperatures, and increased algal productivity with its associated dissolved oxygen swings.*[p. 14]

and

> *Both projected sea level rise and [BDCP] are also anticipated to cause the average location of* X_2 *to move upstream during the summer and fall. The effects analysis acknowledges this result, but … concludes that habitat restoration and food web enhancement will greatly offset this loss of habitat value. The conclusion is in part speculation and in part does not reflect current scientific understanding.* [p. 13].

In response to these critiques, the consultant preparing the BDCP Effects Analysis admitted that, "*The larger question regarding how flow and habitat restoration interact in terms of effects on covered fish, the information and tools we would need to address this issue in the EA do not exist.*" [p. 10]

[Grimaldo, L., Miller, R., Peregrin, C., Hymanson, Z. 2012. Fish Assemblages in Reference and Restored Tidal Freshwater Marshes of the San Francisco Estuary. San Francisco Estuary and Watershed Science, 10(1). Available at: http://escholarship.org/uc/item/52t3x0hq.pdf]

This paper documents the results of fish sampling in 1998 and 1999 at a reference marsh and at several tidal marshes that were unintentionally restored as a result of levee breaches. Fish were sampled in both shallow and deeper water. The surveys found that the flooded islands were dominated by introduced fish species (native species were only 2% of the total catch), particularly where submerged aquatic vegetation (SAV) was found. The authors found that, "*Flooded islands dominated by SAV will likely support an abundance of introduced fishes, especially centrarchids. Thus, lower priority should be given to potential restoration sites that are at elevations likely to favor SAV colonization,*"[Grimaldo et al. 2012:17]. Because islands in the central and south delta are substantially below sea level, the authors suggested that habitat restoration efforts may need to focus on the North Delta, where SAV concentrations are lower and potential restoration sites are near sea level. The authors cautioned that, "*Our study findings indicate that newly restored habitats in the Sacramento–San Joaquin Delta will be invaded by introduced fishes,*" [Grimaldo et al. 2012:1].

The National Research Council's 2012 report also raised concerns that habitat restoration may not yield substantial benefits for listed species, and could cause harmful impacts, particularly if newly restored habitats are colonized by *Corbula amurensis* and other invasive clams, stating that:

> *A more subtle effect of transport on primary production is that transport can couple regions of high productivity with regions that are strong sinks for primary production due to benthic grazing (Lucas et al. 2002), such that increasing*

> *residence time can reduce the accumulation of phytoplankton biomass. As an aside, this points to a possible problem with proposals (e.g., in the BDCP) to increase primary production in the system by increasing shallow water habitat: if that shallow water habitat includes a significant biomass of benthic grazers, it may become a net sink for primary production and so will decrease the total phytoplankton biomass available for pelagic grazers like zooplankton.* [NRC 2012:58].

The NRC panel also cautioned that restored habitats are likely to be dominated by nonnative species.

iv. New Scientific Information Demonstrates that Freshwater Flow Mediates "Other Stressors"

In the 2010 Delta Flow Criteria proceedings, much was made of the opportunities to better understand the mechanisms by which freshwater flow benefits native species. In some cases, these mechanisms were well understood at the time. For example, the Board heard evidence that Sacramento splittail spawning and growth of Chinook salmon juveniles is supported by floodplain inundation, presumably because of the creation of suitable incubation habitat for splittail and generation of food items for the salmon. In other cases, the mechanism driving the well established, durable, and high magnitude correlations between flow and abundance are less certain – probably because there is not a single mechanism but a complex, interconnected, and perhaps context-dependent set of factors driving the relationships.

The Board does not need a complete technical understanding of the mechanistic processes by which increased freshwater flow leads to positive population responses in order to establish protective objectives in the Bay-Delta Plan. The highly significant correspondence between flow and abundance (for instance) provides a more than adequate basis for such objectives. Furthermore, it is important not to regard freshwater flow and other stressors as unrelated, independent factors. Freshwater flow is integral to numerous ecosystem processes (e.g. related to temperature, transport, turbidity, particle retention, water quality, etc.); as a result, reductions in freshwater flows tend to exacerbate other stressors to fish populations and vice-versa. For example, Dugdale et al. (2007) recognized that the impacts of their hypothesized ammonium loading mechanism would be strongly influenced by Delta flow rates and Jassby and Van Nieuwenhuyse (2005) revealed the impact of reduced Delta inflow on the dissolved oxygen barrier to fish migration that prevails in the Stockton Deepwater Ship Channel.

Since 2010, new publications have highlighted the central role played by flow in the operation of numerous potential "other stressors" in the San Francisco Estuary. For example:

[Winder, M., A.D. Jassby, and R. Mac Nally. 2011. Synergies between climate anomalies and hydrological modifications facilitate estuarine biotic invasions. Ecology Letters 14: 749–757. Available at: http://online.sfsu.edu/~modelds/Files/References/Winder2011EcolLetters.pdf]

Winder et al. (2011) conducted retrospective analyses of the correspondence between species invasions and fresh water flow rates in this ecosystem and concluded:

> *Hydrological management exacerbated the effects of post-1960 droughts and reduced freshwater inflow even further, increasing drought severity and allowing unusually extreme salinity intrusions. Native zooplankton experienced unprecedented conditions of high salinity and intensified benthic grazing, and life history attributes of invasive zooplankton were advantageous enough during droughts to outcompete native species and colonise the system.* [p. 794]

Similarly, the life history conceptual model for longfin smelt (Rosenfield 2010; cited above) clearly show that Delta freshwater outflow is the dominant driver of survival ("transition probability") for early life stages of this native fish and that it drives many other potential stressors on longfin smelt abundance, productivity and distribution, including:

- quality and availability of incubation habitat,
- direct entrainment at water diversions,
- concentration and diversity of toxins,
- transport and spatial distribution of larval longfin,
- marine migrations, and
- availability of prey.

Also, in their "Red Flag Reviews" of 2011's draft Bay Delta Conservation Plan (cited above) the fish and wildlife trustee agencies, wrote:

> *Increased residence times and reduced flushing of the Delta by Sacramento River water appear likely to result in interior-Delta channels that are further dominated by agricultural runoff, invasive aquatic vegetation, warmer temperatures, and increased algal productivity with its associated dissolved oxygen swings. These environmental conditions favor nonnative/invasive species (e.g. Egeria densa, largemouth bass, water hyacinth, Microcystis) and disfavor native fishes. The Delta is already more biologically similar to a lake than it once was, due to the historical accumulation of human modifications. We expect that by reducing Delta flows, the Preliminary Project would likely facilitate the spread of habitat conditions that are unfavorable to delta smelt, and less favorable to other target fish species survival and recovery.* [pp. 14-15].

II. FALL DELTA OUTFLOW AND LOW SALINITY ZONE HABITAT CONDITIONS

The Flow Criteria Report concluded that increased fall Delta outflow was necessary to improve habitat conditions for Delta smelt, and it recommended that X_2 be located west of 74 km in Wet years and west of 81 km in Above Normal years ("Fall X_2 Action"),[4] with delta outflow for other water year types consistent with the 2006 Bay-Delta Water Quality Control Plan (SWRCB 2010: 98-99, 108-112). The report classified this as a Category B recommendation, calling for implementation in an adaptive management framework. Scientific studies and publications since

[4] This is consistent with the requirements of the U.S. Fish and Wildlife Service's 2008 biological opinion.

2010, particularly the preliminary monitoring and study results from implementation of the adaptive management plan for the Fall X_2 Action in 2011, provide additional support the Board's conclusions in 2010.

A. ***New Information Regarding Changes in Fall Outflow Over Time and Causes***

[Enright, C. and S.D. Culberson. 2010. Salinity trends, variability, and control in the northern reach of the San Francisco Estuary. San Francisco Estuary and Watershed Science, 7(2).[5] Available at: http://escholarship.org/uc/item/0d52737t.pdf]

This paper documents a substantial reduction in delta outflow during fall months in the 1968 to 2006 period, concluding that the reductions in outflow during the fall "likely reflect increased fall pumping after the 1994 Delta Accord." This paper also documents how delta outflow has become decoupled from precipitation, with the reduction in outflow due primarily to water export operations, as discussed in detail above.

[Feyrer, F. 2012. Declaration of Frederick V. Feyrer In Support of Defendants' Opposition to Plaintiffs' Motion for Injunctive Relief, July 1, 2011. (Doc. 944)]

In this declaration, Feyrer compared average September to December X_2 locations following wet and above normal year types for the periods 1930-1967 (pre-project), 1968-1999 (post-project), and 2000-2009 (post-project) (Figure 8). He also examined changes in the CVP/SWP export: inflow ratio during these same periods (Figure 9). The analysis in this declaration shows that increased water exports and other CVP/SWP operations have reduced Fall X_2 in recent years.

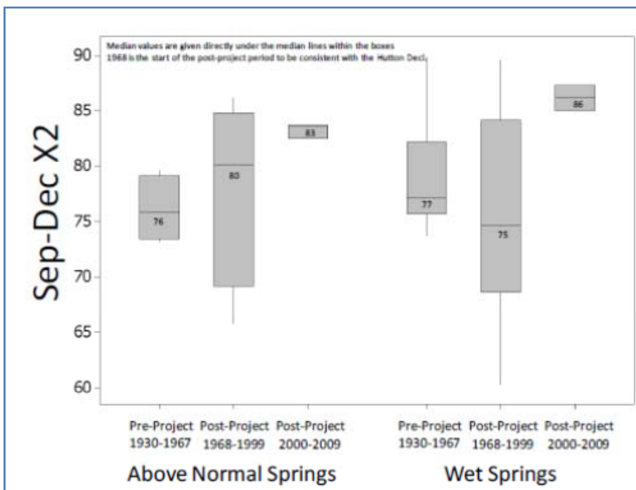

Figure 11. Box plots of X2 for three time periods following above normal and wet springs.

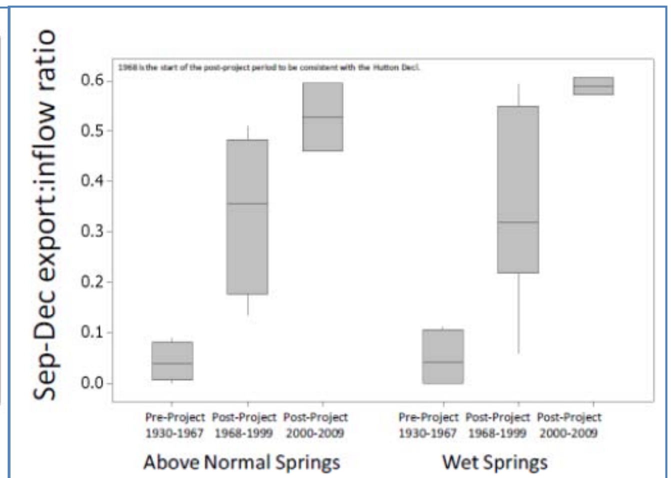

Figure 10. Box plots of export:inflow ratio for three time periods following above normal and wet springs.

Fig. 8 (Reprinted from Feyrer 2012)

Fig. 9 (Reprinted from Feyrer 2012)

[5] This paper was published during the 2010 proceeding, but it was not cited in the 2010 Flow Criteria Report.

B. *New Scientific Publications Regarding the Effects of Fall outflow on fish populations and lower trophic levels*

[Feyrer, F., K. Newman, M. Nobriga, and T. Sommer. 2010. Modeling the Effects of Future Outflow on the Abiotic Habitat of an Imperiled Estuarine Fish. Estuaries and Coasts. DOI 10.1007/s12237-010-9343-9. Available at: http://www.dwr.water.ca.gov/aes/docs/FeyrerNewmanNobrigaSommer2010.pdf]

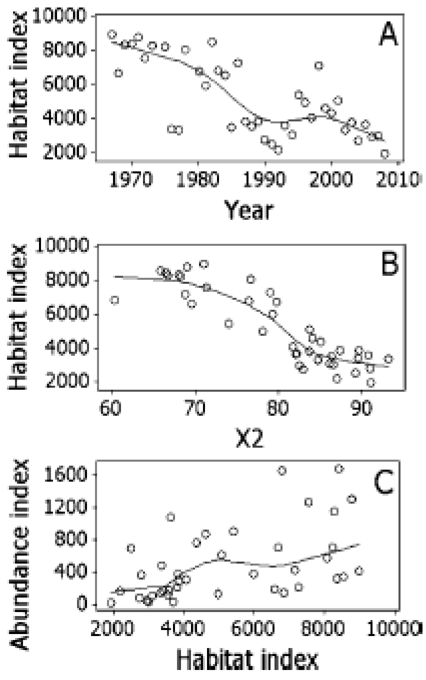

Fig. 2 Plots of the habitat index time series (**a**), relationship between *X2* (km) and the habitat index (**b**), and relationship between the habitat index and delta smelt abundance measured as the fall midwater trawl index. Curves are LOESS smooths

Fig. 10 (Reprinted from Feyrer et al 2010)

This paper documents a substantial decline in the abiotic habitat quality for delta smelt from 1967 to 2008, using a generalized additive model to relate habitat quality (temperature, salinity, and turbidity) with the probability of occurrence of delta smelt. The model predicts continued decline in fall habitat quality as a result of climate change. In addition, this habitat index was positively correlated with the Delta smelt abundance index, but there was more variability in abundance at higher habitat values; in other words, low habitat values are correlated with low abundance, but high habitat values are correlated with both high and low abundance (*See* Figure 10). The authors hypothesized that increased habitat area lessens the likelihood of density-dependent effects on the Delta smelt population and lessens the probability of stochastic events, such as a major pollution event that causes substantial mortality.

[T. Sommer, F. Mejia, M. Nobriga, F. Feyrer, L. Grimaldo. 2011. The Spawning Migration of Delta Smelt in the Upper San Francisco Estuary. San Francisco Estuary and Watershed Science, 9(2). Available at: http://escholarship.org/uc/item/86m0g5sz.pdf]

The paper concludes that the over the past 20 years, the distribution of delta smelt during the pre-migration period (fall) is in the low salinity zone, and that fish distributions in the fall are highly significantly related to the location of X2. The paper acknowledges that an unknown portion of the population occurs in the Cache Slough region, an area that is not consistently sampled in the FMWT, but concludes that the FMWT provides the best available information to analyze long term trends in Delta smelt abundance and distribution.

[Baxter, R. R. Breuer, L. Brown, L. Conrad, F. Feyrer, S. Fong, K. Gehrts, L. Grimaldo, B. Herbold, P. Hrodey, A. Mueller-Solger,T. Sommer, K. Souza. 2010. Pelagic Organism Decline

Work Plan and Synthesis of Results. Interagency Ecological Program, Sacramento, CA. Available at: http://www.water.ca.gov/iep/docs/FinalPOD2010Workplan12610.pdf]

This report summarizes the synthesis of research on the pelagic organism decline. It finds that fall habitat quality for delta smelt has significant declined, and that there is evidence that this habitat decline has had and continues to have population level consequences for delta smelt. It states that "there is good evidence for reduction in habitat availability and suitability during the fall and a linkage of these reductions with abundance." The report also proposes that changes in salinity and outflow are the most important environmental drivers of the pelagic organism decline, including the problem of recent fall outflows being low regardless of water year type.

[BDCP "Red Flag" Documents [California Department of Fish and Game; US Fish and Wildlife Service; and National Marine Fisheries Service. April 2012 BDCP EA (Ch. 5) Staff "Red Flag" Review Comprehensive List. Available at: http://baydeltaconservationplan.com/Libraries/Dynamic_Document_Library/Effects_Analysis_-_Fish_Agency_Red_Flag_Comments_and_Responses_4-25-12.sflb.ashx]

The BDCP "Red Flag Staff Reviews" (2012; cited above) comments by the regulatory agencies on the February 2012 draft BDCP identify the agencies' concerns regarding the exclusion of the Fall X_2 Action from that BDCP proposal. In particular, DFG concluded that there is reasonable evidence that recent changes in water management in the Delta have substantially degraded fall habitat for delta smelt, that this has contributed to the pelagic organism decline, and there is great uncertainty the potential benefits of tidal habitat restoration and food production will offset the negative effects of fall habitat degradation. FWS similarly stated that reduction in flows (in terms of magnitude, timing, and variability) is the most fundamental cause of stress and driver of change in the Delta ecosystem. FWS also stated that:

> *Both projected sea level rise and the Preliminary Proposal are also anticipated to cause the average location of X_2 to move upstream during the summer and fall. The modeling indicates that intra-annual variability would be lost for several months in the late summer and fall in all water year types; even wet years would functionally become dry years for a third of delta smelt's life cycle. The effects analysis acknowledges this result, but the Net Effects concludes that habitat restoration and food web enhancement will greatly offset this loss of habitat value. The conclusion is in part speculation and in part does not reflect current scientific understanding.*
>
> *This has several implications for delta smelt. First, under the preliminary project delta smelt habitat would less frequently lie in Suisun Bay and Marsh during summer and fall. The habitat suitability modeling shows that this would limit the capacity of tidal marsh restoration in the Suisun region to contribute to delta smelt production. Second, lower summer outflows would increase the length of time that seasonal delta smelt habitat constriction occurs and overlaps with physiologically stressful water temperatures. This means that more food production would be required to maintain current delta smelt growth and survival rates, even in areas where temperatures remain suitable. In areas where*

> *temperatures exceed physiologically suitable levels during the summer (~ 24°C), no amount of food production will increase growth or survival rates. Third, the restricted distribution of delta smelt during most summers and essentially all falls would increase the chance that a localized catastrophic event could pose a serious threat to the survival of the delta smelt population.* [p. 13].

[U.S. Fish and Wildlife Service 2012. First Draft 2011 Formal Endangered Species Act Consultation on the Proposed Coordinated Operations of the Central Valley Project and State Water Project. Available online at: http://www.usbr.gov/mp/BayDeltaOffice/docs/Signed_FINAL%202011-F-0043_%20SWP-CVP%20BO%20Dec%2014%20FIRST%20DRAFT.pdf]

The draft biological opinion released by the U.S. Fish and Wildlife Service in December 2011 acknowledged that several recent life cycle models (Mac Nally 2010; Thomson 2010) did not find correlations between Fall X_2 and Delta smelt abundance.[6] The draft biological opinion states there are reasonable explanations why the partial life cycle models (Feyrer 2007, Feyrer 2010) found such a relationship whereas the other models have not: whereas the life cycle models examined changes in the FMWT index from year to year, the Feyrer analyses examined changes from the FMWT index to the STNS index (from adult to juvenile abundance). As a result, "*This time step may therefore just be too long to track the population-level effects of fall habitat conditions – especially since the concurrent habitat influence on each year's FMWT index is already encompassed in the indices themselves*." (FWS 2012: 269). In the draft BiOp, the Service repeated the analysis in Feyrer 2007, using updated FMWT and TNS data and using average X_2 values instead of specific conductance; the draft BiOp finds that:

> *The linear regression showed that fall relative abundance is a highly significant predictor of the next generation's relative abundance (logTNS = 0.742*logFMWT – 1.34; r2 = 0.65; P < 0.000001; AICc = 16.21). Then, we re-ran the linear regression including fall X_2 as a covariate. Consistent with Feyrer et al. (2007), the analysis indicated that both fall relative abundance and fall X2 were significant predictors of the relative abundance of juveniles the next summer (logTNS = 0.703*logFMWT – 0.0252*X2 + 0.872; P < 0.000001; AICc = 14.20). Note that the AICc for the stock-recruit model including fall X2 is two units lower than the model without it, suggesting the regression model that includes X2 provides a better fit to the data (Burnham and Anderson 1998 as cited by Maunder and Deriso 2011).* [p. 270]

The draft biological opinion concludes that these analyses support a population-level effect of fall outflow conditions, but acknowledge that the full life cycle models do not show such an effect. (FWS 2012:271).

[6] The life cycle model prepared by Maunder & Deriso (2011) is also discussed in the draft biological opinion. The published life cycle model did not include Fall X2 as a covariate to analyze.

C. New Scientific Information From the Fall X2 Adaptive Management Plan Monitoring and Studies on the Effects of Fall Outflow on Delta Smelt and Lower Trophic Levels

SUMMARY: Preliminary results from 2011 Fall X2 Action Suggest the Action Contributed to Reduced *Corbula* Grazing Pressure, Increased Phytoplankton and Zooplankton Abundance, and Increased Delta Smelt Growth and Abundance

[Brown, L., R. Baxter, G. Castillo, L. Conrad, S. Culberson, G. Erickson, F. Feyrer, S. Fong, K. Gehrts, L. Grimaldo, B. Herbold, J. Kirsch, A. Mueller-Solger, S. Slater, T. Sommer, K. Souza, and E. Van Nieuwenhuyse. 2012. Synthesis of Studies in the Fall Low Salinity Zone of the San Francisco Estuary, September – December 2011. Available at: http://deltacouncil.ca.gov/sites/default/files/documents/files/FLaSH_combined_7_0_12.pdf][7]

[U.S. Bureau of Reclamation, 2011. Draft Plan: Adaptive Management of Fall Outflow for Delta Smelt Protection and Water Supply Reliability. Available at: http://deltacouncil.ca.gov/sites/default/files/documents/files/Materials_Reviewed_Fall_Outflow_Mgmt_Plan_2011_06_06_review_draft_b.pdf]

[Thompson, J., K. Gehrts, F. Parchaso, and H. Fuller. 2012. Going with the flow: the distribution, biomass and grazing rate of *Potamocorbula* and *Corbicula* with varying freshwater flow (May and October 2009-2011). Progress Report to U.S. Bureau of Reclamation, Sacramento, CA.]

[Teh, S. 2012. Fall X2 fish health study: contrasts in health indices, growth and reproductive fitness of delta smelt and other pelagic fishes rearing in the low salinity zone and Cache Slough regions. Progress Report to Environmental Restoration Program, California Department of Fish and Game, Sacramento, CA.]

[Baxter, R. and S. Slater. 2012. Delta Smelt Distribution & Diet Fall 2011. Presentation to the Delta Science Program independent scientific peer review of the Fall Low Salinity Zone (FLASH) Studies and Adaptive Management Plan Review. Available at: http://deltacouncil.ca.gov/sites/default/files/documents/files/Baxter_Slater_Flash_DeltaScienceJuly2012_v2.pdf]

Calendar year 2011 was classified as a wet water year type, triggering the Fall X_2 action and the associated scientific monitoring and adaptive management program (Brown 2012). The adaptive management plan for the Fall X_2 Action in 2011 included specific monitoring programs and scientific studies, and included testable hypothesis and predictions. Although the Fall X_2 Action was not fully implemented due to court injunctions, on average in 2011 X_2 was located at 75 km for the months of September and October (Brown et al 2012). This resulted in X_2 locations that are substantially different from the most recent previous wet year of 2006 (82 km) or 2010 (85 km) (Brown 2012).

[7] This draft report was publicly released as part of the Delta Science Program's independent scientific peer review of the Fall Low Salinity Zone (FLASH) Studies and Adaptive Management Plan Review. The document has not been finalized, and all conclusions therein are preliminary and subject to revision.

The analysis of monitoring and studies associated with the Fall X_2 Action in 2011 continues, and similar scientific studies and monitoring programs will be implemented in 2012, when no Fall X_2 Action will occur. The preliminary results from monitoring and scientific studies of the 2011 Fall X_2 Action required under the adaptive management plan are discussed below. In addition, Figure 11 on page 32 (reprinted from Brown 2012) provides a preliminary assessment of the Fall X2 Action measured against the testable hypotheses identified in the adaptive management plan.

1. **<u>Effects of Fall Outflow on Delta Smelt Abundance</u> –**

The 2011 adaptive management plan warned that, "*Delta smelt are rare, and a simple calculation reveals that we cannot expect to detect an abundance difference in the FMT after a single year of flow augmentation unless the abundance difference is very large*." (USBR 2011:18). The adaptive management plan predicted that implementation of the Fall X_2 Action at 74 km in 2011 would result in the fall abundance of Delta smelt reversing its declining trend. (USBR 2011). This prediction was more than met (Brown 2012; *see* Figure 7). According to the California Department of Fish and Game, the Fall Midwater Trawl Index of Delta smelt, a measure of abundance of delta smelt, was at its highest levels since 2001 and this "*improvement is likely due in large part to higher than usual Delta outflow which resulted in more and better habitat.*" (CDFG, 2011).

In addition, the adaptive management plan examined the relationship between the FMWT and the TNS survey, as an indicator of delta smelt present in the summer surviving into the fall. The plan hypothesized that the ratio of FMWT population index to TNS population index would be higher in years when X_2 is at 74 km, like 2011 (Brown 2012:36-37, 60-61). The report concludes that:

> *This ratio was well above the median in 2011; however, this may be at least partially the result of favorable summer conditions and resulting high survival rather than only favorable fall conditions and survival. The ratio of TNS to the FMWT of the previous year (Fig. 47) can be used as an indicator of successful recruitment of juveniles from the maturing adults sampled by the FMWT. This suggests that the increase in FMWT population index in 2011 resulted from a combination of favorable factors in the winter, spring, and summer preceding the fall. The data suggests that survival in the fall and preceding summer months was likely higher than other years, supporting the prediction for survival (Table 1*) [p. 61].

2. **<u>Effects of Fall Outflow on Abundance and Filtration Rates of Invasive Clam species (*Corbula* and *Corbicula*)</u>**

One hypothesis to explain why the Fall X_2 action should benefit Delta smelt is that it limits grazing pressure of invasive clams (*Corbula*) on phytoplankton abundance, thus contributing to more productive food webs for delta smelt. The adaptive management plan predicted that *corbula*[8] biomass in the LSZ would be higher at X_2=85 (2010) and lower at X_2=75 (2011). Brown (2012) concludes that this prediction was met:

> *Based on biomass, Potamocorbula were less abundant in Grizzly/Honker Bay and western Suisun Marsh during October 2011 compared to 2009 and 2010 (Fig. 43), supporting the prediction (Table 1). These differences were even more apparent in the turnover rate which normalizes the Potamocorbula grazing rates to the depth of the water column (Fig. 44).* [pp. 57-58].

More directly, the progress report submitted by the principal investigators to the Bureau of Reclamation for this study concludes that:

> "*Relative to the previous two dry years, the biomass of bivalves was decreased in the shallow portions of Grizzly and Honker Bays and in Western Suisun Marsh (including Montezuma and Suisun Slough) in 2011. The reduction in biomass was sufficient to limit the potential for bivalves to control phytoplankton biomass accumulation in fall.*" [Thompson 2012:1].

Thompson found that there was a statistically significant difference in biomass and grazing rate in the Grizzly/Honker Bay shallows and the Western Suisun March in 2011 as compared to 2010 and 2009. As the authors noted:

> "*The location of these decreased grazing rates is important as we might expect pelagic primary producers to do best in the shallows of Grizzly and Honker Bays and we might expect that marsh production would have a better chance of reaching other consumers when the bivalve grazers were greatly reduced as seen in 2011.*" [p. 5]

The principal investigators hypothesized that, "*the increasing salinity in fall that began in 1999 allows fall larvae to settle further upstream,*" in "*traditionally lower salinity areas,*" (Thompson et al. 2012:2-3). Once established in these areas, the authors hypothesize that the bivalves are more resistant to winter spring outflow and this results in higher grazing rates in the following spring. The authors found that, "*the fall grazing rates were sufficient to potentially limit phytoplankton biomass accumulation in 2009-2010 but not in 2011.*" (Thompson 2012:6).

The authors conclude that, "*the reduction in bivalve biomass and therefore grazing in 2011 could be due to recruitment losses in spring or fall and our ongoing work with the monitoring station samples should help delineate the cause,*" (Thompson 2012:6). However, the report also documents that *Potamocorbula* biomass was very high in the fall of 2006, despite the very wet spring that year. Further monitoring and studies are underway, including monitoring in 2012, to better identify the specific mechanism.

---

[8] Thompson 2012 identifies the species as *Potamocorbula*, whereas Brown 2012 identifies them as *corbula*.

3. Effects of Fall Outflow on Phytoplankton Abundance

The adaptive management plan predicted that average phytoplankton biomass in the LSZ (excluding *Microcystis*) would be higher at X_2 is at 74 km, and measured concentrations of chlorophyll-a (a common surrogate for phytoplankton biomass) to test this hypothesis (Brown et al 2012). Although some monitoring suggested that the hypothesis was not met, the USGS data supported the hypothesis, and the draft report concluded:

> *Chlorophyll-a concentrations were highest in the LSZ during Sep-Oct compared to all the other years compared, with concentrations lowest in 2005 and 2006. Concentrations were greatest in Sep-Oct 2011 compared to other years across all salinity regions. High concentrations continued in the LSZ in Nov-Dec. In the other salinity regions, concentrations were more comparable across years. Although the EMP and USGS data are somewhat in conflict, we provisionally suggest that the prediction of higher phytoplankton biomass at low X_2 is supported, but the other part of the prediction at higher X_2s is uncertain. We give greater weight to the USGS data because of its slightly greater spatial coverage and observations made by experienced researchers during the EMP and USGS cruises.* [Brown et al. 2012:53].

In addition, investigators observed a significant phytoplankton bloom of long chained diatoms was observed in the fall of 2011, which had not occurred in recent years.

4. Effects of Fall Outflow on Delta Smelt Health and Growth Rates –

The majority of Delta smelt were caught in the low salinity zone in the fall, with a few fish caught in the Cache Slough area (Teh 2012; Baxter 2012). In general, analysis of Delta smelt health and condition showed they were generally in good condition, but there were not sufficient baseline data to compare with 2011 results (Teh 2012). In addition, the study found that:

> *"Otolith growth rates revealed that fish during the fall of 2011 were growing at a high rate, highest since 2000, however we did not observe a difference in growth among different habitats."* [Teh 2012:3].

Additional studies of otolith growth rates are ongoing.

5. Effects of Fall Outflow on Zooplankton Abundance

DFG compared the results of zooplankton sampling in 2011 with earlier years. The results show that adult copepod densities (catch per unit effort, or CPUE) was generally higher in 2011 than in 2010, 2006, or 2005 for *P. forbesi* and *A. sinesis*, both in the low salinity zone and in freshwater. (Baxter 2012). Adult mysid densities were substantially higher in the low salinity zone in 2011 than in those prior years, whereas in freshwater mysid abundance was lower in 2011 in some months. (Baxter 2012) Brown 2012 found that, *"The prediction was that calanoid copepod biomass would be greater in the LSZ with low X_2 and the data did show that trend; however, given the high uncertainty in the data, a definite conclusion is not warranted."* (p. 55).

	Predictions for X2 scenarios		
	85 km	81 km Year used to test prediction	74 km
Variable (Sep-Oct)	2010 (X2=85)	2005, 2006 (X=83,82)	2011 (X2=75)
Dynamic Abiotic Habitat Components			
Average Daily Net Delta Outflow	~5000 cfs?	~8000 cfs?	11400
Surface area of the fall LSZ	~ 4000 ha	~ 5000 ha	~ 9000 ha
Delta Smelt Abiotic Habitat Index	3523	4835	7261
San Joaquin River Contribution to Fall Outflow	0	Very Low	Low
Hydrodynamic Complexity in LSZ	Lower	Moderate	Higher
Average Wind Speed in the LSZ	Lower	Moderate	Higher
Average Turbidity in the LSZ	Lower	Moderate	Higher
Average Secchi Depth in the LSZ	Higher	Moderate	Lower
Average Ammonium Concentration in the LSZ	Higher	Moderate	Lower
Average Nitrate Concentration in the LSZ	Moderate	Moderate	Higher
Dynamic Biotic Habitat Components			
Average Phytoplankton Biomass in the LSZ (excluding *Microcystis*)	Lower	Moderate	Higher
Contribution of Diatoms to LSZ Phytoplankton Biomass	Lower	Moderate	Higher
Contribution of Other Algae to LSZ Phytoplankton biomass at X2	Higher	Moderate	Lower
Average Floating *Microcystis* Density in the LSZ	Higher	Moderate	Lower
Phytoplankton biomass variability across LSZ	Lower	Moderate	Higher
Calanoid copepod biomass in the LSZ	Lower	Moderate	Higher
Cyclopoid copepod biomass in the LSZ	Lower	Moderate	Moderate
Copepod biomass variability across LSZ	Lower	Moderate	Higher
Corbula biomass in the LSZ	Higher	Moderate	Lower
Predator Abundance in the LSZ	Lower	Moderate	Higher
Predation Rates in the LSZ	Lower	Moderate	Higher
Delta Smelt (DS) Responses			
DS caught at Suisun power plants	0	0	Some
DS in fall SWP & CVP salvage	Some?	0	0
DS center of distribution (km)	85 (77-93)	82 (75-90)	78 (70-85)
DS growth, survival, and fecundity in fall [a]	Lower	Moderate	Higher
DS health and condition in fall	Lower	Moderate	Higher
DS Recruitment the next year	Lower	Moderate	Higher
DS Population life history variability	Lower	Moderate	Higher

[a] Only survival from summer to fall as the ratio of FMWT population index to TNS population index was assessed.

Fig. 11 (Reprinted from Brown 2012:63-64). Predictions that were supported by the data are highlighted in green, and predictions that were not supported by the data are highlighted in red. Predictions highlighted in gray indicate that data are not yet available to support a conclusion, and predictions with no shading indicate that there is no data to assess whether the prediction was met or not.

III. LIMITATIONS ON THE USE OF THE BDCP EFFECTS ANALYSIS IN REVISING THE BAY-DELTA WATER QUALITY CONTROL PLAN

The State Board properly concluded that its 2010 Flow Criteria Report was based on the best available science. As detailed in this written submission, subsequent scientific reports and publications since 2010 overwhelmingly support the Board's conclusion. In contrast, as we noted above in the context of the hypothesis that physical habitat restoration can offset further flow reductions, both independent peer reviewers and state and federal fish and wildlife trustee agencies have repeatedly concluded that the Bay Delta Conservation Plan Effects Analysis fails to use the best available science. Because of its deeply flawed analytical approach, the Board should not rely on BDCP's effects analysis in this proceeding. In addition, the Board should consider independent scientific peer reviews of future iterations of the BDCP effects analysis (or require such review if it has not occurred) before relying on BDCP's scientific conclusions.

[National Research Council, 2011, A Review of the Use of Science and Adaptive Management in California's Draft Bay Delta Conservation Plan. The National Academies Press, Washington, DC. Available at: http://www.nap.edu/catalog.php?record_id=13148]

In 2011, the National Research Council (NRC 2011) reviewed the November 18, 2011 working draft chapters of the BDCP, and found critical gaps in the BDCP. The panel was not provided with the draft effects analysis. The NRC panel noted that the draft document:

> *"… creates the impression that the entire effort is little more than a post-hoc rationalization of a previously selected group of facilities, including an isolated [water] conveyance facility, and other measures for achieving goals and objectives that are not clearly specified."* [NRC 2011:43].

This independent review specifically commended the use of DRERIP conceptual models (such as Rosenfield 2010, described above), the IEP POD conceptual framework, specific goals and objectives, and the independent science advisor's adaptive management framework (which clearly identified uncertainties). The review concluded that, "*It is nearly impossible to evaluate the BDCP without a clear specification of the volume(s) of water to be diverted, whose negative impacts the BDCP is intended to mitigate.*" [p. 4].

[Red Flag memos (cited above)]: The Department of Fish and Game, U.S. Fish and Wildlife Service, and National Marine Fisheries Service identified substantial methodological flaws, stating that the Effects Analysis has a tendency to "*overstate Plan benefits*", "*turn the notion of uncertainty upside down*," made unjustified conclusions, relies on "*combat science*," "*deals with the critical concept of uncertainty inconsistently and does not effectively integrate, use, and report uncertainty in the Net Effects*," uses inadequate conceptual models, "*underemphasizes Bay-Delta water flows as a system-wide driver of ecosystem services to the San Francisco Estuary*," relies on selective use of data and models, ignores the best available models for splittail and longfin smelt, and "*continues to insist on an analytical approach to entrainment that does not reflect the best available science*." [*See esp*. pp. 1-2, 5, 8-10, 11-12, 15-17]

In particular, the agencies identified substantial flaws with the analysis of changes in spring outflow on longfin smelt, changes in fall outflow on delta smelt, and the analysis of impacts to the low salinity zone, with FWS concluding that:

> *"In summary, the current Effects Analysis does not appropriately deal with critical issues involving the role of the Low Salinity Zone as habitat for longfin smelt, delta smelt, and splittail. Until it addresses the right questions regarding flow, LSZ location, and turbidity, we are reluctant to rely on its conclusions."* [Red Flags 2012: 13-14; *see also* pp. 5-7, 12, 16]

[Parker, A., Simenstad, S., George, T., Monsen, N., Parker, T., Ruggerone, G., and Skalski, J. Bay Delta Conservation Plan (BDCP) Effects Analysis Phase 2 Partial Review, Review Panel Summary Report. Delta Science Program 2012. Available at: http://deltacouncil.ca.gov/sites/default/files/documents/files/BDCP_Effects_Analysis_Review_Panel_Final_Report_061112.pdf]

In June 2012 an independent peer review panel convened by the Delta Science Program issued its report reviewing the BDCP's draft effects analysis. The report states that:

> *…the Panel universally believes Chapter 5: Effects Analysis fails to achieve the fully integrated assessment that is needed to draw conclusions about such a momentous Plan. By missing or obscuring key concepts and specifics, it falls short of presenting an analytical framework for a compelling and rigorous analysis of whether and how the BDCP would achieve its biological and other objectives.* [p. 4].

The review panel concluded that, "*As it is currently written, the Effects Analysis is too inconsistent in its treatment of how effects are analyzed across listed species and the potential costs and benefits of the planned BDCP activities are too uncertain to provide an objective assessment of the BDCP on covered species*," (p. 5). The panel also found that:

- The effects analysis failed to adequately incorporate biological goals and objectives;
- The net effects assessment "*needs greater objectivity*," "*are substantially misleading*," and should be subject to independent peer review;
- The effects analysis ignores potential negative impacts of habitat restoration and other conservation measures;
- The effects analysis fails to address uncertainty systematically; and,
- The analysis of food resource availability and the effects of habitat restoration "*is grossly incomplete and overly simplistic*" [*see esp*. Parker 201:13-15, 21-25, 26-29, 34-36]

Question 2. How should the State Water Board address scientific uncertainty and changing circumstances, including climate change, invasive species and other issues? Specifically, what kind of adaptive management and collaboration (short, medium, and long-term), monitoring, and special studies programs should the State Water Board consider related to ecosystem changes and the low salinity zone as part of this update to the Bay-Delta Plan?

Response to Question 2: Recommendations to Address Scientific Uncertainty and Changing Circumstances

The basic questions to be addressed by adaptive management are: (1) how will the Delta ecosystem respond to implementation of the Bay-Delta Plan? and, (2) how should the Plan be modified as new information becomes available and/or new circumstances alter ecosystem conditions? These questions cannot be adequately answered until the Board has clearly defined desired ecosystem conditions and instituted a framework for designing, implementing, and modifying Bay-Delta Plan objectives over time to best achieve the desired response.

The foundation of that adaptive management framework is in the identification of biological outcomes for fish and wildlife species strongly influenced by flow and water quality parameters and bio-physical outcomes for the ecosystem as a whole. These outcomes (referred to here as "targets", but generally in other fora as "objectives") are defined such that they are specific, measureable, achievable, relevant to the particular goals that characterize the plan's overarching purpose (protecting the public trust values and beneficial uses of the Delta ecosystem) and time-bound (S.M.A.R.T.) – this level of specificity and detail being necessary for orienting, enforcing, measuring and evaluating progress of, and calibrating the adaptive management effort. The framework is completed by ensuring that information relevant to evaluating the Plan's performance is collected and evaluated, and future actions (ranging from accelerated review to large-scale modifications) and the conditions that trigger those actions are established as part of the program of implementation. In other words, adaptive management requires management targets (desired outcomes), a method of evaluating progress towards those targets (monitoring and data evaluation), and specific decision pathways that describe how, when, and under what circumstances new information is used to modify the implementation of the Plan. Recent insights into the impact of global climate change on the Bay-Delta ecosystem and its watershed (Null, S.E. and J.H. Viers 2012) emphasize the need for the Board to clearly articulate S.M.A.R.T. management targets and adaptive management decision-pathways in advance as this will establish the basis for recognizing when corrective action is required and how those corrective actions will be determined.

I. A LOGIC CHAIN ARCHITECTURE FOR PLANNING RESTORATION OF PUBLIC TRUST VALUES IN THE BAY DELTA

We propose using what we have termed a "Logic Chain" decision architecture for revising the Bay-Delta Plan and adaptively managing its implementation and subsequent modification. By posing a series of increasingly specific questions, the Logic Chain forces articulation of a Plan's desired outcomes, proposed actions to achieve those outcomes, and expected results of those actions. These questions are described in the attached "Logic Chain User's Guide" (Appendix

A), modified here from that which we developed for the Bay Delta Conservation Plan (BDCP). The orientation of different elements of the Logic Chain is displayed in the attached "Logic Chain Architecture" diagrams (Appendix A).

To apply the Logic Chain approach to revising the Plan, the Board must first identify in broad terms what the Plan is intended to accomplish in protecting public trust values and beneficial uses (i.e., 'Goals"). These should be short declarative statements that describe outcomes of a successful plan; there may be numerous different plan goals (e.g. at least one for each species or ecosystem characteristic of interest). Each Goal is associated with a S.M.A.R.T. (specific, measureable, achievable, relevant (to the goal), and time-bound) target (or "objective" in non-Clean Water Act usage) that describes unambiguously what attainment of the goal looks like.

A. Goals and SMART Targets

Goals and SMART targets are policy decisions informed by the best available science. Policy makers have set statutory and legal thresholds for restoration and recovery of native species, natural communities, and other public trust ecosystem values through enactment of the state and federal Clean Water Acts (CWA), state and federal Endangered Species Acts (CESA, ESA), the Central Valley Project Improvement Act (CVPIA), the California Natural Communities Planning Act (NCPA), and other laws. In implementing these legal mandates, the fish and wildlife trustee agencies have, in many cases, promulgated goals and targets related to achieving restoration and recovery thresholds. For example, NMFS and USFWS have developed draft recovery standards for Central Valley salmonids (NMFS 2009) and native pelagic species (FWS 1995). Further description of restoration targets for anadromous fish species are contained in the CVPIA's Anadromous Fish Restoration Program (AFRP) and products developed from implementation of the San Joaquin Settlement Act (USBR 2011). Furthermore, in adopting the flow criteria in the 2010 report the Board linked those criteria to the likely occurrence of specific desired outcomes for public trust resources. TBI et al (2010, exhibits 1-4) and CDFG (2010), in particular, provided the Board with detailed information regarding the population viability attributes of native estuarine species that are most strongly affected by flow conditions, and identified thresholds for viable populations that can and should be used to guide the setting of flow-related objectives in the Plan. These sources provide a surfeit of material from which the Board can develop its own set of goals and SMART targets calibrated to achieving its responsibilities under the Clean Water Act and the public trust and we incorporate them fully by reference.[9]

As we defined the term in our previous testimony (TBI et al. 2010, exhibits 1-4), "viability" means the maintenance of acceptable levels or conditions of four different biological characteristics that relate to the persistence of populations and estuarine ecosystems:

- Abundance
- Spatial distribution
- Diversity and
- Productivity

[9] We understand the Board's interest in having previous testimony cited referenced very specifically (by page, paragraph, etc.); however, given the volume of relevant information in TBI et al. (2010, exhibits 1-4) and CDFG (2010), such specific references would be inefficient and burdensome to the reader.

These terms were further defined by the National Marine Fisheries Service for "viable salmonid populations" (McElhany et al. 2000; Lindley et al 2007) and they are widely accepted as the relevant characteristics for gauging population viability in the field of conservation biology (e.g. Meffe and Carrol 1994).

Viable populations exhibit levels of each of these four characteristics that protect them from extirpation. The level of each of these attributes that represents protection of public trust values may equal or exceed those required to maintain viability, but the public trust cannot be maintained at values of these population attributes that represent non-viability of important species. Brief descriptions of the four viability attributes follow:

1. Abundance Targets

The number of organisms in a population is a common and obvious species conservation metric. More abundant populations are less vulnerable to environmental or human disturbances and risk of extinction and reflect a higher level of protection of public trust values. Populations or species with low abundance are less viable and at higher risk of extinction than large populations for reasons that include 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. Sufficient population abundance is necessary, but not sufficient alone, to guarantee viability into the future.

Example: In our 2010 testimony (TBI et al. exhibit #2), we suggested the Board adopt an abundance target for longfin smelt recommended by the US Fish and Wildlife Service in its draft Delta Native Fishes Recovery Plan (FWS 1995). That draft recovery plan indicated that longfin smelt would be considered recovered (with respect to abundance) when:

> *… its population dynamics and distribution pattern within the estuary are similar to those that existed in the 1967-1984 period. This period was chosen because it includes the earliest continuous data on longfin smelt abundances and was a period in which populations stayed reasonably high in most years…*[p. 56].

As discussed elsewhere in this submission and our previous testimony (TBI et al. 2010, Exhibit #2), longfin smelt population abundance is strongly correlated with Delta outflow; thus, population abundance targets can and should be scaled to prevailing annual hydrology. Unless the abundance target is corrected for hydrology, it may not be achievable during very dry periods and may not be relevant to the restoration goal during very wet periods (when attainment of the 1967-1984 average population could represent underperformance). We suggest that the abundance target for longfin smelt be defined as equaling the abundance *relative to unimpaired hydrology* seen during the 1967-1984 period and that the Board aim for attainment of this target within 6 years of implementation of any new water quality standards.

Note that this target does not suggest that actual Delta outflow approach unimpaired Delta outflow, only that abundance in the future equal or exceed that which occurred under similar hydrological conditions in the 1967-1984 period. Such an approach to a longfin smelt abundance target has the advantage of remaining agnostic on what actions (flow or other) are taken to achieve the target – if habitat restorations or modification of water diversion structures or operations are successful, then it is possible that less actual Delta outflow will be needed to achieve abundances documented in similar hydrological conditions in the past.

2. Spatial Distribution Targets

More widely distributed populations are less vulnerable to catastrophic events and risk of extinction (e.g., MacArthur and Wilson 1967; Meffe and Carrol 1994; Laurance et al. 2002). Therefore, maintaining or restoring spatial distribution of fish and wildlife species is a critical component of protecting these species and maintaining the public trust. 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 effect of geographic distribution on extinction risk is also apparent in the geographic attributes of extant freshwater fish species (Rosenfield 2002). The need to maintain adequate spatial distribution is regularly acknowledged in regulatory planning and decision-making regarding the Delta and its environs (e.g. FWS 1995; NMFS 2009).

Example: Delta smelt spend much or all of their life in the Delta's Low Salinity Zone. The size and geographic extent of this important habitat determines, to a large extent, the boundaries of the Delta smelt population during key parts of their life cycle. If at certain times of year, the LSZ is confined to a small geographic area (as when it is located to the east of Chipps Island where it is confined to narrow River Channels), then all or most of the Delta smelt *in the world* are also located in one area – all of their eggs are in a very small basket such that a catastrophic chemical spill (e.g. the Cantara Loop spill), disease outbreak (e.g. the Klamath salmon kill), predator aggregation, or entrainment event could eliminate the entire population very quickly. This is part of the rationale behind recommendations (ours and those in the FWS 2008 biological opinion) to expand habitat in the fall (e.g. the Fall X_2 action). The Board should describe, based on the best available science and linked to attributes of viability for key species, the desired spatial extent during relevant seasons and year types and then mandate that these spatial extent targets be met immediately upon promulgation of a new WQCP.

3. Diversity Targets

Species and populations that are both more genetically diverse and more diverse in life history patterns are more resilient to environmental change and less at risk of extinction. Natural diversity needs to be protected both within populations of native species in the Bay-Delta and in the habitats and processes of the ecosystem as a whole. Natural diversity (e.g. life history patterns) allows organisms to adapt to and benefit from environmental variability. This is an especially important characteristic in highly variable ecosystems such as the Delta. Flow criteria should also address the natural diversity of natural communities through specific targets for seasonality, frequency, and duration of freshwater Delta outflows. 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.

Life history diversity provides the protection for species in time that spatial distribution provides in space – the risk and rewards are distributed across the population. The historic variability in the timing of the Delta's peak flows (e.g. Kimmerer 2004; Enright and Culberson 2010) is reflected in the life history of the Delta's native species; Delta smelt and longfin smelt display protracted spawning periods in this ecosystem, for example (Nobriga and Herbold 2010; Rosenfield 2010). The success of these different life history timings depended on the availability of resources (e.g. food, spawning conditions) in the next, unpredictable phase of the life cycle. By restricting "beneficial" flow periods to short time windows (e.g. VAMP), policy makers attempt to make native species' life histories uniform and predictable. But, if individual success still depends on future conditions that are unpredictable, then such artificial and rigid constraints on life history transformations that are triggered by flow may eventually lead to an entire population missing its "window of opportunity". Flow variability (frequency variation in magnitude, seasonality, and duration) within the Delta is a natural part of the ecosystem and flow criteria should insure both the maintenance of appropriate variability and the maintenance of the life history diversity that allows public trust resources to adjust to and thrive within that variability regime.

Example: The natural (historical) breadth of life history timing are known for several species that depend on the low salinity zone are well-documented. Just as the size and extent of the LSZ will be governed by the WQCP, the Board should ensure that the size and location of this critical habitat is maintained the approximate duration reflected in historical patterns of key species. In order for the target to be S.M.A.R.T., the Board will need to establish target dates for attainment of the desired duration of specific low salinity zone conditions.

Allowing for sufficient time for expression of life history diversity within populations will be absolutely essential as these organisms (and the Board) grapple with the changing seasonality of resource availability that is expected under global climate change scenarios. It is important to note here that the Board's formulation of flow criteria in its 2010 report based on a percentage of unimpaired as a multi-day running average, would by its nature tend to preserve the seasonality of peak flow events and flow troughs. Under this formulation, both the specific percentage of unimpaired flow and the averaging period for that flow that the Board requires will determine both the magnitude of peak flows *and their duration*.

4. Productivity Targets

A population's potential for population growth allows it to adjust 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. 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). Rapid and large declines in species abundance produce "genetic bottlenecks" that may constrain viability of a species for many generations even after abundance has recovered. Similarly, 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.

Example: As described above, current water management practices in the Central Valley result in (a) disproportionate impact to winter-spring Delta outflow and the Low Salinity Zone habitat when natural (unimpaired) hydrological conditions are dry (Figure 2) and (b) an extremely high frequency of naturally rare and devastating (super-critical) actual Delta outflow conditions (Figure 3). The frequency of extreme drought conditions and the truncation of the other, wetter end of the flow spectrum persistently reduce population and overall ecosystem productivity in the Bay-Delta – simply, the system is heavily impacted frequently and not allowed to recover when conditions would otherwise allow for recovery. The Board can improve ecosystem and population productivity of LSZ-dependent species by setting minimum flow frequency thresholds (e.g. super-critical years can occur at a maximum of 1 in 20 years and wet years must occur at least 3 of every 4 years in which hydrological conditions permit) and by insuring that water development impacts are more equitably distributed across water year types – we note that the Board's formulation of flow criteria in its 2010 report based on a percentage of unimpaired as a multi-day running average, would standardize the proportional effect of water development regardless of hydrological condition. Targets for restored productivity are necessarily defined as acceptable return frequencies for different conditions; the Board can and should establish a time-bound for attainment of these ecosystem productivity targets that allows for detection of natural patterns and deviations from those natural patterns (e.g. non-attainment).

B. STRESSORS AND STRESSOR REDUCTION

Stressors are those forces that are believed to inhibit attainment of the Plan's goals and SMART targets. Uncertainty may manifest in different views regarding which forces limit recovery of public trust values or the relative strength of different stressors. One benefit of the Logic Chain Architecture is that it does not require an a priori ranking of different stressors; multiple stressors can be processed simultaneously. Instead, assumed stressors are treated as hypotheses about what limits attainment of goals and objectives so that stressor reduction targets (the next level of the Logic Chain) can be written in the following form:

> *"If* [stressor x] *is limiting attainment of* [target y*], then we can attain the target by reducing* [stressor x*] by* ___ [insert specific, measureable reduction] *by* ___ [insert date]*"*

Examples of stressors that might be relevant to restoration of public trust values and beneficial uses of the Delta ecosystem include (but are not limited to):

- limited low salinity zone rearing "habitat" (characteristics of which would be specifically defined)
- inadequate transport/retention of larval fish (or food/nutrients)
- inadequate flushing of pollutants (toxins or nutrients)
- inadequate access/attraction to/from tributary habitats
- impaired migration due to physico-chemical blockages
- inadequate food production

Technical experts should be surveyed to determine whether the stressor reduction threshold is sufficient to produce measureable progress towards the related SMART target *if* (assuming) the stressor is actually operative.

Note that, during completion of the upper parts of the Logic Chain (description of goals, targets, stressors, and stressor reduction thresholds), it is undesirable to imply that a problem will or must be solved through a particular course of action; that is, we should not confuse the purpose of a plan (its goals and targets) with the means employed to attain those ends.

C. Actions (Flow Objectives)

Actions describe the measures that will be taken to reduce stressors and thus attain the SMART stressor reduction targets. Measures to reduce stressors should be implemented commensurate with (1) the magnitude of the action's effect, (2) the degree of scientific certainty regarding the action's effect and our ability to alleviate the stressor, (3) the speed with which remedies can be implemented, and (4) our ability to increase certainty and/or performance of the conservation strategy (i.e. our ability to learn from the action). Effort and resources expended addressing a stressor should also be inversely proportional to the risk of unintended and irreversible consequences from taking action. Actions to improve freshwater flow conditions in the Delta rate highly in each of these decision criteria because they are relatively certain to alleviate multiple stressors on multiple species, they can be implemented rapidly, and they are easy to modify (or undo) as we learn more and/or conditions change.

Implementing flow-related objectives is the main action that the Board will take in revising the Bay-Delta Plan to help ameliorate stressors (meet stressor reduction thresholds) in order to achieve ecosystem-wide goals and targets. More than one action may be required to fully address a particular stressor and individual actions may affect more than one stressor. The Board can and should describe the expected outcomes of each objective it promulgates – how much is each action expected to achieve (magnitude)? And how certain are we that the desired effect will be realized? Identification of the magnitude and certainty of an action's expected outcomes should not imply that the Board will only take actions with a high impact and high degree of certainty (although these are obviously preferred); rather, identifying the magnitude and certainty of outcomes for each action allows the Board to assess the potential for a suite of actions to attain sufficient stressor reduction and attainment of plan goals and targets. If numerous actions have relatively low certainty of producing positive impacts, then we would clearly want to identify additional measures that can "take up the slack" if expectations for one or more measures are not met.

II. The Logic Chain's Role in Adaptive Management

By clearly describing the Bay-Delta Plan's goals and targets with respect to desired outcomes for public trust values and beneficial uses of the Delta ecosystem and by articulating the pathways by which those outcomes will be attained, completion of the Logic Chain lays the groundwork for effective and transparent adaptive management of flow standards in the future. Well-articulated desired outcomes for biological and physical conditions of the future (S.M.A.R.T. targets) serve as beacons for management action; for instance, a management response is clearly required whenever targets are not attained by their specific time-frame. Thus, simply by defining relevant achievable targets in a specific and time-bound manner, the Board begins to define a decision pathway for adaptive management of the Plan. Similarly, the Logic Chain architecture forces planners to identify the key assumptions (which stressors are being addressed? how much do they need to be reduced to achieve the objective?) and uncertainties (will this action contribute more or less than expected to reducing its associated stressor? will it generate unforeseen negative outcomes?) that then become the focus of adaptive management monitoring and targeted research as detailed in the Plan's program of implementation.

Obviously, the nature of the performance monitoring and evaluation regime is critical to the success of the adaptive management framework we have described. At a minimum, in the program of implementation the Board should require implementation of monitoring and research activities equivalent to those in the existing monitoring and research program identified in the 2011 fall outflow adaptive management plan, with monitoring implemented in all water year types, as modified to ensure adequate evaluation of attainment of biocriteria and other SMART targets. The monitoring results and adaptive management decisions (implementation of decision tree framework) should be subject to independent peer review, and the results of the monitoring and adaptive management plan should be synthesized and peer reviewed every three to five years. At each subsequent review of this Bay Delta Plan, the Board should review the synthesis of results and peer review to consider changes to the Plan to better attain SMART targets and protect beneficial uses and the Public Trust.

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APPENDIX A

THE LOGIC CHAIN: TERMS AND APPLICATIONS
A User's Guide for the Bay-Delta Plan Update

BACKGROUND AND NEED

The San Francisco Bay-Delta and its watershed are home to numerous imperiled species, including (but not limited to) those that are officially protected by the federal or state Endangered Species Acts. The watershed is also the source for much of California's agricultural, municipal, and industrial water supply. Planning efforts to reconcile these two, often competing, demands are underway (e.g. BDCP, DSP, WQCP).

The process of developing and implementing a plan that would allocate sufficient water to meet these different needs is extremely complex. Restoration planning is complicated by the number and diversity of imperiled and/or recreationally/commercially valuable species, the physical complexity of the Delta, and uncertainty about the nature and strength of cause-effect relationships operating in this ecosystem. Furthermore, the ecosystem is changing in ways that are relatively well understood (e.g. sea level rise), incompletely understood (e.g. pelagic organism decline), and those that are unknown.

The Logic Chain architecture is designed to (1) standardize terminology used in the planning process, (2) increase clarity and specificity regarding expected outcomes of plan implementation (e.g. to allow evaluation of a conservation plan prior to its implementation), and (3) develop the inputs that will be necessary for adaptively managing plan implementation as efficacy of the plan is evaluated and actions are adjusted accordingly. This document serves to describe and define tiers of the Logic Chain so there is a shared understanding of its terms, the questions underlying different components of the architecture, and expectations of a comprehensive plan description.

The Logic Chain articulates a pathway from a plan's Goals and Targets, to the specific actions designed to achieve those aspirations, to the monitoring, research, and metrics that will capture the effects of the conservation actions, and through specific adaptive management decision pathways that adjust conservation effort in light of progress made towards Goals and Targets. The Logic Chain captures the underlying rationale and assumptions for the actions that comprise the overall conservation strategy ("the plan") and establishes benchmarks against which progress can be measured. This approach increases specificity and clarity regarding:

- desired outcomes and specific targets for recovery of covered species and ecosystem attributes;
- the stressors assumed to impede attainment of these outcomes;
- the plan's strategy for stressor-reduction;
- the conservation actions and their expected outcomes; and
- the metrics that will be monitored and studies performed to evaluate plan success.

The clarity and specificity of a Plan's articulation of the components of its Logic Chain affect our understanding of the data collection, analysis, synthesis, and evaluation processes that enable adaptive management. By articulating what the conservation strategy is trying to accomplish and how it intends to achieve its targets, the Logic Chain architecture facilitates both evaluation of the initial plan and assessment of its efficacy during implementation. Specific decision pathways (what decisions are necessary? when and how are they made? by who? how are the decisions implemented?) must be outlined in advance in order to maintain the Logic Chain's focus on attainment of desired outcomes.

THE LOGIC CHAIN – HOW IT WORKS

By capturing the answers to a standard set of questions, the Logic Chain architecture provides a means for explaining the challenges to ecosystem restoration and maintenance of public trust values and how a given conservation strategy intends to address those impediments. These questions and their position within the Logic Chain are described below. *The Logic Chain does not identify specific legal obligations (e.g. as spelled out in permit terms or water rights decisions); rather, it forms the basis for determining those obligations*. As our knowledge base grows (through initial evaluation and subsequent implementation of a plan and as a result of ongoing monitoring and research) management uncertainty can be reduced, allowing increased efficiency and efficacy in allocation of conservation effort.

LOGIC CHAIN QUESTIONS AND ASSOCIATED TERMINOLOGY

Below are examples of the questions that drive various levels of the Logic Chain. Each question calls for a particular type of information; labels for these Logic Chain components are indicated with underlining and italics and also appear on the associated schematic diagrams.

What's the problem? Numerous fish species in the Sacramento-San Joaquin Delta ecosystem are officially endangered or otherwise imperiled; collectively, they reflect a decline in various ecosystem functions and a diminution of public trust values. Ecosystem processes (such as floodplain inundation, primary and secondary productivity, and transport and retention of organisms, toxins, and nutrients) have been radically altered in this ecosystem. For each of several target species and for the ecosystem as a whole, *problem statements* provide a concise declaration of the ecological issues that a conservation plan will address. Problem statements are general and objective descriptions of the problem(s) and do not assume particular causes of, or solutions to, those problems.

What outcome(s) will solve the problem? The Logic Chain describes species and ecosystem attribute-specific *global goals* – general statements that disaggregate the problem statement into its various components. There may be more than one Goal associated with each problem statement. Goals represent desired outcomes that will solve the issue(s) identified in the problem statement. Again, these are simple, factual statements (that rely on trustee agencies' expert opinion) and do not pre-suppose a mechanism for solving the problem. The goals are "global" because they describe outcomes that may be partially or completely beyond the scope of any single plan. Still, identification of these global goals is important to create a context for the overall conservation strategy. Global goals and associated targets are delineated by the fish and wildlife trustee agencies (e.g., as identified in the various conservation/recovery plans).

How will we know then the global goal has been attained (what does solving the problem look like)? *Global targets* provide specificity to the desired biological or physical outcome (goal). Targets are specific, measureable, attainable, relevant to the goal, and time-bound (S.M.A.R.T.) statements of what level of restoration constitutes attainment of the goal. Global targets provide a clear standard for measuring progress towards a goal. As with global goals, global targets may be only partially relevant to the activities of a particular plan; their function is to define the magnitude of the problems so that investment in conservation activities is appropriate to the magnitude of the conservation challenge.

What currently prevents us from attaining the global targets? Physical, chemical, and biological attributes of the Delta have changed dramatically over the past several decades (and that change is expected to continue into the future). Some of these changes are *stressors* to covered species and important ecosystem processes. However, the precise contribution of each stressor to a species' population decline is uncertain and there is some disagreement over whether particular changes are stressors at all.

Our knowledge base (data, publications, conceptual and quantitative models) suggests which stressors are operating on particular species or ecosystem values. Describing the stressors (and assumptions about them) accurately and comprehensively is a key step in constructing a conservation plan and in managing adaptively as the plan is implemented. For example, clear statements regarding where a stressor occurs, which species/ecosystem attributes it impacts, and how certain we are that the stressor is important will help focus planning on the relevant stressors; ranking stressors is unnecessary at this stage because the logic chain elements that come after stressor identification provide insight into a stressor's potential magnitude and certainty as well as our ability to address the stressor – understanding these facets of assumed stressors is necessary in order to prioritize them.

Some stressors are beyond our control or beyond what we choose to control. For example, annual weather patterns (unimpaired hydrology) and ocean conditions cannot be impacted by local or regional conservation measures. Similarly, some problems may be beyond the geographical or legal scope of any given conservation plan. These *unmanaged stressors* are described in the planning process for two reasons: (1) so that it is clear that other stressors may affect ecosystem performance and (2) so that these stressors can be monitored/measured and used to more clearly reveal the true impacts of plan implementation (e.g. they may be used as covariates in an any analysis of ecosystem performance).

What will the plan do to reduce stressors? Stemming from the stressors identified for each species and the ecosystem, *Plan Targets* identify the scope of perceived problems that the plan will address. As with global goals and targets, stressor reduction targets are S.M.A.R.T. statements that clarify the plan's intentions; they articulate a desired outcome resulting from implementation of the conservation measures. These targets reveal the relative effort dedicated to alleviating each stressor and provide a basis for assessing whether the conservation measures will (cumulatively) achieve the plan's stressor reduction target (see *expected outcomes* below).

System-wide monitoring metrics and programs will be identified as a means of tracking progress towards stressor reduction (plan targets), global goals, and global objectives. Monitoring must also track unmanaged stressors because plan effectiveness will be judged after accounting for variance in these "background conditions" (because, for example, a spate of dry years would be expected to result in low abundance of many species and productive ocean conditions would be expected to contribute to higher returns of anadromous fishes). Data from monitoring plans will be collected, synthesized, and evaluated by an independent entity (to be defined) that is charged with evaluating plan effectiveness and advising policy-makers about ongoing adaptive management actions.

What actions will be taken reduce stressors (achieve the plan's targets)? The conservation strategy consists of a number of different actions that address one or more of the stressors identified above for one or more of the key species or ecosystem attributes). In order to estimate their value, importance, and overall contribution to plan success, these *conservation actions* must be described in terms of their expected contribution to stressor reduction. In addition, potential negative impacts and unintended consequences of the conservation measures should be described in the same detail as intended (positive) impacts. Furthermore, the logic chain requires an indication of the likelihood (certainty) that conservation measures will produce their anticipated effects (both positive and negative). Very few actions will have outcomes that are extremely certain; that is not a reason not to proceed with the action. The purpose of estimating an actions certainty of success is to (a) gauge its worth against other actions (high magnitude, high certainty actions being worth somewhat more than low magnitude, or low certainty actions) and (b) to enable evaluation of the certainty of the plan as a whole and the need for more or less aggressive action.

How will these actions achieve the goals and targets? In order to understand the value of each action (e.g. to prioritize implementation) and to assess the strength of the entire proposal, the planning process will convene teams of scientists and technical advisors to make detailed and, where possible, quantitative estimates of *expected outcomes* (positive and negative/unintended outcomes that are anticipated) from each conservation measure. Expected outcome magnitudes will be accompanied by estimates of the *uncertainty* surrounding the magnitude. In this way, the potential efficacy of the proposed plan can be evaluated prior to permit issuance and the plan's accomplishments can be assessed as implementation proceeds.

The magnitude of expected outcomes and uncertainties surrounding those outcomes will be based on explicit hypotheses about how we expect conservation measures to work. To the extent possible, conservation measures will be designed, implemented, and monitored in a way that allows testing the hypotheses upon which they are based. Information gathered from *compliance and performance monitoring* will be synthesized and evaluated to assess the validity of different hypotheses and the efficacy of the conservation actions and the overall plan; conservation effort and the array of conservation actions will be adjusted to make continuing progress towards the plan's stressor-reduction targets.

How will we know if it's working (and adjust if it's not)? Given the uncertainties inherent in managing such a large and complicated estuarine environment, a San Francisco Bay-Delta conservation strategy is expected to employ adaptive management – "learning to manage by managing in order to learn". Monitoring at various levels (system-wide, compliance, and measure performance) will capture physical, chemical, and biological changes in the ecosystem in order to determine the effectiveness of the overall plan and its component parts as well as ongoing changes in response to other drivers (e.g. climate change).

Data collection, analysis, synthesis, and evaluation are critical to plan success. Appropriate management structures for each of these processes should be established as part of an initial action plan. Furthermore, the means by which new information (e.g. lessons learned during early stage implementation) is incorporated into adaptive management decisions (decision pathways) should be described in detail prior to plan implementation as part of the BDCP governance process.

Adaptive management processes are characterized by dashed lines on the attached figure because they generally remain ill-defined; but, the details of how a plan responds to data, analysis, and emerging conditions should transparent from an early stage – their description cannot be delayed until plan implementation is under way. In particular, performance targets for conservation actions, stressor reduction (*stressor or plan targets*), and global targets must be S.M.A.R.T. Procedures for taking action when these targets are not being attained should be defined in advance. As one example, there should be pre-determined operating instructions that describe how will managers respond when, despite performance-as-expected of conservation measures, stressor reduction targets are not attained?

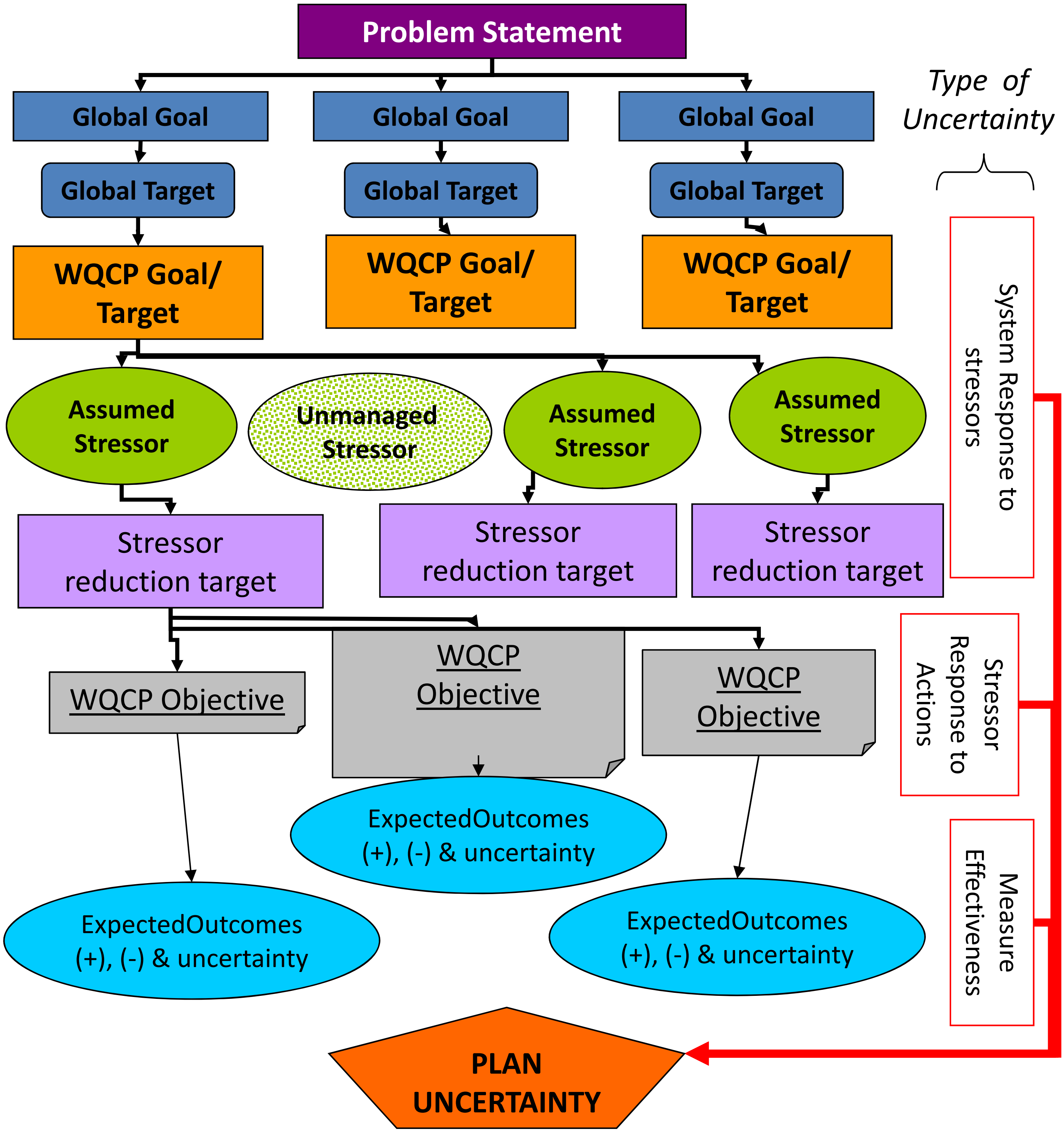
PRIORITIZATION PRINCIPLES

How should we choose between competing actions? Conservation actions must be prioritized to maximize the effect of limited resources, to provide rapid relief for the Bay-Delta's imperiled species, and to insure that the conservation strategy is based on the best available information and understanding of the target species and the Delta ecosystem. Factors that influence the prioritization of conservation measures include:

- Likelihood of positive and negative outcomes
- Magnitude and breadth (number of species affected) of positive and negative outcomes
- Time required to develop and document positive outcomes
- Ability to implement the action (e.g. financial, legal, and logistical constraints).
- Reversibility

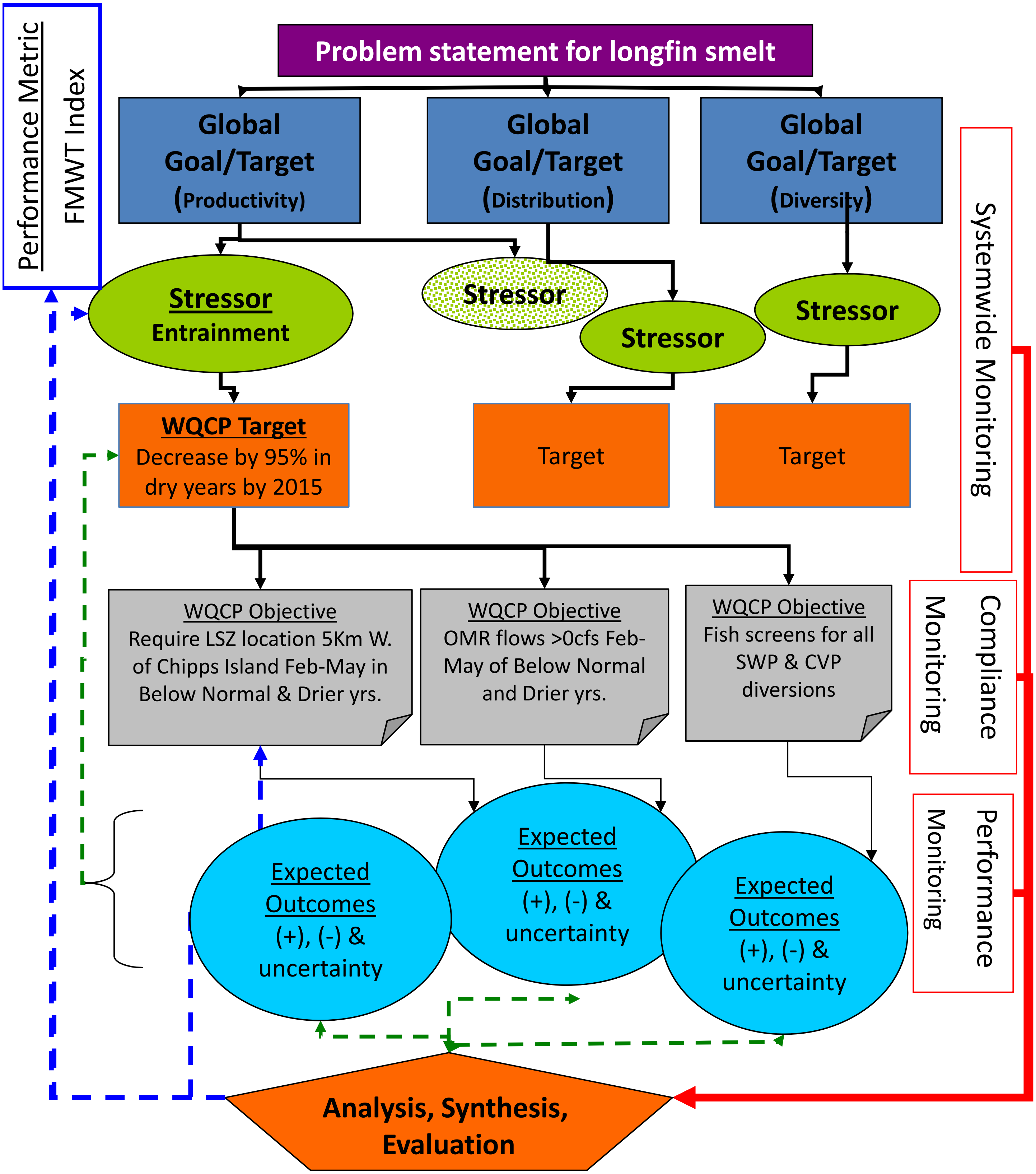
These principles should guide description of actions in the plan and be addressed explicitly as part of the justification for each plan element (conservation action).

The Logic Chain Architecture



Relationship of Logic Chain elements to each other and to different types of uncertainty faced by the planning process. Ideally, each "problem" that the Plan hopes to address has its own logic chain. The inclusion of "Global" Goals and Objectives into the logic chain is a recognition that the WQCP, nor any other plan, is intended to address all aspects of ecosystem or population restoration in the Central Valley – WQCP Goals and Targets represent this Plan's contribution to overarching restoration outcomes.

Incorporating Flow into WQCP Planning



Schematic showing how hypothetical State Board actions are integrated by the Logic Chain into conservation planning for a native fish species of the Low Salinity Zone. Monitoring (red boxes) have been inserted where the Logic Chain identified assumptions/uncertainties. Black lines indicate the connection between Logic Chain elements in the planning process. Green dashed lines suggest some of the necessary pre-project evaluations. Blue lines represent post-implementation adaptive management decision pathways that must be specified in advance.

Additional Scientific Information Related to Salmonids, Recommended Changes to the Bay-Delta Water Quality Control Plan, and Recommendations to Address Scientific Uncertainty and Changing Circumstances

Workshop 2: Bay-Delta Fishery Resources

Submitted by:
Trout Unlimited
&
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Submitted to the State Water Resources Control Board on behalf of:
Trout Unlimited
The Bay Institute
Natural Resources Defense Council
Pacific Coast Federation of Fishermen's Associations

September 14, 2012

I. Response to Question 1: Additional Scientific Information and Recommended Changes to the Bay-Delta Water Quality Control Plan Regarding Salmonids

The State Water Resources Control Board (State Water Board) is requesting information related to the comprehensive Phase 2 review and update to the 2006 Water Quality Control Plan for the San Francisco/Sacramento-San Joaquin Delta Estuary (Bay-Delta Plan). Specifically, the State Water Board seeks scientific and technical information that was not addressed in its 2009 Staff Report or its 2010 final report on "Development of Flow Criteria for the Sacramento-San Joaquin Delta Ecosystem" (hereafter 2010 Delta Flow Report or SWRCB 2010). We recognize that many different public trust resources are impacted by the conditions in the Sacramento-San Joaquin Delta (Delta); however this submittal focuses on new scientific and technical information related to anadromous species that rely on the Delta, mainly Chinook salmon (*Oncorhynchus tshawytscha)*.

Anadromous fish utilize the Delta for a number of critical functions including spawning, rearing, migration (both upstream as adults and downstream as juveniles) and foraging. However, they also utilize upstream riverine habitats to complete essential life functions. Therefore, Delta flow requirements (both inflow and outflow) must be sufficient to provide the contiguous habitat that is necessary to support the life cycle of Chinook salmon and other anadromous species. To truly understand what flow requirements are sufficient, it is necessary to understand not only the in-Delta requirements of Chinook salmon life history but also the upstream relationships between flow and Chinook salmon survival. The characteristics of inflow to the Delta are positively correlated with flow characteristics in the upstream watershed. Therefore, a range of flow characteristics in the upstream watershed drive a variety of processes that promote sustainable conditions for salmon and other anadromous fish species as well as the overall ecological health of the Delta.

The current Delta hydrograph has been dramatically altered over time by both water exports from the Delta and diversions throughout the watershed. These alterations have resulted in the significant deterioration of the ecological health of the Delta and the Public Trust resources it supports, including salmonids. Habitat alterations in the Delta limit salmon and steelhead production primarily through reduced survival during the outmigrant (smolt) stage. Decreased flow can delay juvenile migration events resulting in their increased exposure to unsuitable water temperatures, predation or entrainment. These lower survivals are associated with decreases in the magnitude of flow through the estuary, increases in water temperature, and water project diversions in the Delta.

An extensive amount of scientific information supports the concept that the magnitude, duration, frequency and timing of flow is critical to the restoration of natural anadromous fish resources in the Central Valley watershed. In addition to survival being higher with higher flows, Chinook salmon abundance has also been found to be higher with greater Sacramento River (and San Joaquin River) flow. Therefore, adequate freshwater flow both into the Delta and through the Delta is an absolute prerequisite to increasing salmon survival rates and restoring natural salmon production in the Central Valley.

Scientific literature and other technical information that has become available since 2010 strongly supports the State Water Board's 2010 Delta Flow Report finding that "*the best available science suggests that current flows are insufficient to protect public trust resources.*" (2010 Delta Flow Report, p.2). In the context of anadromous fish, the information reinforces the finding that Chinook salmon have diverse life histories and life cycles that require suitable conditions in the upper and lower watersheds, Delta and ocean. The information also supports the finding that the drastic changes to the quality and characteristics of historic salmonid habitat, largely caused by water diversion activities, have resulted in decreased Sacramento Valley Chinook salmon and steelhead stocks. Salmonids are adapted to the seasonally variable stream flows and diverse habitats of Central Valley rivers. Water management and diversion activities have helped create a system that deviates from these historical conditions. This deviation and associated decrease in the dynamism of the system has degraded habitat and created an environment conducive to alien species that compete with juvenile salmon for prey or predate upon them.

In this written submission, we review and summarize the findings of new publications, studies, and data and conclude that these new studies and publications support the following findings:

1. California's native fish communities are experiencing rapid decline with the majority at risk of extinction and trends in decline having accelerated markedly over the last three decades.
2. All Central Valley Chinook salmon populations as well as Central Valley steelhead populations are now sufficiently impacted to be endangered or at least vulnerable to extinction, with the most significant mechanisms of their decline being loss of access to upstream tributary spawning and downstream floodplain rearing habitats and large-scale flow alterations.
3. Delta inflow levels and patterns exert a strong influence over the growth, survival, movement, and life history diversity of migratory species that rely on them. Juvenile Central Valley Chinook salmon, specifically, are reliant on and affected by flow levels in the Delta.
4. The scientific literature strongly suggests that restoring floodplain connectivity and restoring flow regimes in both the Delta and its watershed are the restoration actions below major dams most likely to result in direct benefits to salmon and other species, by ameliorating flow and temperature changes (including effects of climate change), increasing habitat diversity and population resilience, improving juvenile survival and transport to marine environments, and facilitating efficient and timely return of adult salmonids to upstream spawning habitats.
5. Increased flows, improved habitat quality and connectivity, and increased access of fish to improved channel and floodplain habitat can all, individually and in concert, have a positive effect on survival.

These new studies and publications also support the State Water Board's findings in the 2010 Delta Flow Report that:

1. Existing flows are inadequate to protect Public Trust resources.

2. Winter/Spring inflows should be substantially increased, using a percentage of unimpaired flows approach.
3. Releases from upstream sources should be made proportionally to each stream and watershed to preserve ecological connectivity between the Delta and upstream watersheds, increase the spatial distribution (and hence, distribution of risk) of salmon spawning populations, and avoid concentrating impacts on a subset of source areas.
4. Limitations on reverse flows in Old and Middle River (OMR), closures of the Delta Cross Channel gates, inflow: export restrictions, and other objectives are necessary to provide adequate migratory pathways through the Delta for juvenile and adult salmonids.

The State Water Board should complement these changes to the Bay-Delta Plan objectives with the adoption and implementation of a clear, transparent, and fully-defined adaptive management strategy that establishes specific, measureable, achievable, relevant and time-bound targets for protection of fish and wildlife beneficial uses.

A. POPULATION STATUS OF CENTRAL VALLEY CHINOOK SALMON AND STEELHEAD RUNS

Overall, populations of important Delta anadromous fisheries have been greatly reduced from historic levels, are currently in decline, or both. They all remain highly vulnerable to collapse in response to short-term disturbances, as evident in the collapse of the Sacramento River fall run Chinook salmon in 2008-09, which resulted in the complete closure of the salmon fishery for the first time in California history, and which was attributed to poor oceanic conditions in combination with significantly depressed freshwater conditions. Populations of anadromous fish species (Chinook salmon, steelhead, and green and white sturgeon) remain severely depressed since the State Water Board published its Delta Flow Report (SWRCB 2010). Population responses to improved environmental conditions during their juvenile (freshwater) life stages among Chinook salmon runs are only evident 2-3 years later when these fish return to spawn; thus, flow improvements (relative to those at the end of the last decade) in 2010 and 2011 would only manifest as improved salmon escapement in 2012 and subsequent years. The current anticipated rebound of the fall run Chinook population reinforces that anadromous fish are also very sensitive to positive environmental conditions and have the potential for recovery.

1. New Information on the Risk of Extinction for Native Species

A recent quantitative protocol has determined that all runs of Sacramento Valley Chinook salmon are vulnerable to extinction within the next century and identifies estuary alteration and major dams as the two most significant impacts on anadromous populations.

> [Moyle, P.B., J.V.E. Katz, R.M. Quiñones. 2011. Rapid decline of California's native inland fishes: A status assessment. Biological Conservation (144) 2414–2423]

Moyle and others (2011) applied a quantitative protocol to assess conservation status of all 129 freshwater fishes native to California. Their results indicated that 83% of California's freshwater fishes are extinct or at risk of becoming so, representing a 16% increase since 1995 and a 21% increase since 1989. Additionally, of 31 species officially listed under federal and state endangered species acts (ESAs), 17 (55%) were rated as endangered by their criteria, while 12 (39%) were rated vulnerable (including Central Valley fall, winter and spring run Chinook salmon). Conversely, of the 33 species that received endangered rating by Moyle and others, only 17 (51%) were officially listed under the ESAs. This latter finding points to the insufficiency of the ESA listing as an indicator for collapse in fish populations and the urgent need for actions to promote their recovery.

> [Katz, J., P. B. Moyle. R.M. Quiñones, J. Israel and S. Purdy. 2012. Impending extinction of salmon, steelhead, and trout (Salmonidae) in California. Environ Biol Fish. DOI 10.1007/s10641-012-9974-8]

Katz et al (2012) developed a quantitative protocol to determine conservation status of all salmonids native to CA. Results indicate that if present trends continue, 25 (78%) of the 32 taxa native to California will likely be extinct or extirpated within the next century. As a component of this analysis, results classified Central Valley Late Fall Run Chinook Salmon populations as Endangered and all other Central Valley Chinook Salmon (Fall, Winter, Spring) and Steelhead populations as "Vulnerable" to extinction. Katz quantitative analysis identified major dams (43%) and estuary alteration (43%) as the two most significant ("Critical High") impacts on anadromous populations.

2. **New Information on Population Status of Central Valley Salmon and Steelhead runs**

Based on information from the sources identified below, the population status of Central Valley salmon and steelhead runs remain severely depressed.

> [Kormos, B., M. Palmer-Zwahlen, and A. Low. California Department of Fish and Game. March 2012. *Recovery of Coded-Wire Tags from Chinook Salmon in California's Central Valley Escapement and Ocean Harvest in 2010*. Fisheries Branch Administrative Report 2012-02. Available at: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=44306]

> [National Marine Fisheries Service. February 10, 2012. Biological Opinion for the Department of Water Resources 2012 Georgiana Slough non-physical barrier study. File # 151422SWR2011SA00060 (TN 2011/05837). Available at: http://swr.nmfs.noaa.gov/bo/Georgiana_Slough_Barrier_Study_021012.pdf. ("NMFS 2012a")]

> [National Marine Fisheries Service. August 2011. *5-Year Review: Summary and Evaluation of Sacramento River Winter-run Chinook Salmon ESU*. Available at: http://swr.nmfs.noaa.gov/psd/fyr/Final_Winter-run_Chinook_5-year_Review_Report_082211.pdf ("NMFS 2011a")]

> [National Marine Fisheries Service. January 26, 2012. *Letter from Maria Rea to Ron Milligan regarding Winter Run Chinook JPE during water year 2012*. ("NMFS 2012b")]

[National Marine Fisheries Service. *Annual Report of Activities October 1, 2010, to September 30, 2011, Delta Operations for Salmonids and Sturgeon (DOSS) Technical Working Group.* October 2011. Available at: http://deltacouncil.ca.gov/sites/default/files/documents/files/DOSS_Annual_Report_10_18-11_final.pdf ("NMFS 2011b")]

[National Marine Fisheries Service. *Delta Operations for Salmonids and Sturgeon (DOSS) Working Group. Presentation for the Independent Review Panel, 11-8-11, by Bruce Oppenheim (NMFS) and Thuy Washburn, USBR.* Available at: http://deltacouncil.ca.gov/sites/default/files/documents/files/OCAP_2011_presentations_09_DOSS_ann_rev_11_7_11.pdf ("NMFS 2011c")]

[National Marine Fisheries Service. March 2012. Abundance-based Ocean Salmon Fisheries Management Framework for Sacramento River Winter-Run Chinook. Supplemental NMFS Report 2 to the Pacific Fishery Management Council. Available at: http://www.pcouncil.org/wp-content/uploads/G4c_SUP_NMFS_RPT2_MAR2012BB.pdf ("NMFS 2012c")]

[Pacific Fishery Management Council. April 2012. Preseason Report III: Council Adopted Management Measures and Environmental Assessment Part 3 for 2012 Ocean Salmon Fishery Regulations. Available at: http://www.pcouncil.org/wp-content/uploads/Preseason_Report_III_2012.pdf]

i. Winter Run Chinook Salmon

In recent years, escapement of winter run Chinook peaked in 2006 (the highest level since 1994), but since then, "*escapement estimates for 2007, 2008, 2009, 2010, and 2011 show a precipitous decline in escapement numbers based on redd counts and carcass counts*." (NMFS 2012a: 20). Brood year 2011 marked the fifth consecutive year of declining juvenile numbers and the fifth consecutive year in which the cohort replacement rate[1] was less than 1, indicating a negative growth rate and declining abundance. (NMFS 2012b: 1, NMFS 2012a: 20-21; *see* Fig. 1-2). The Department of

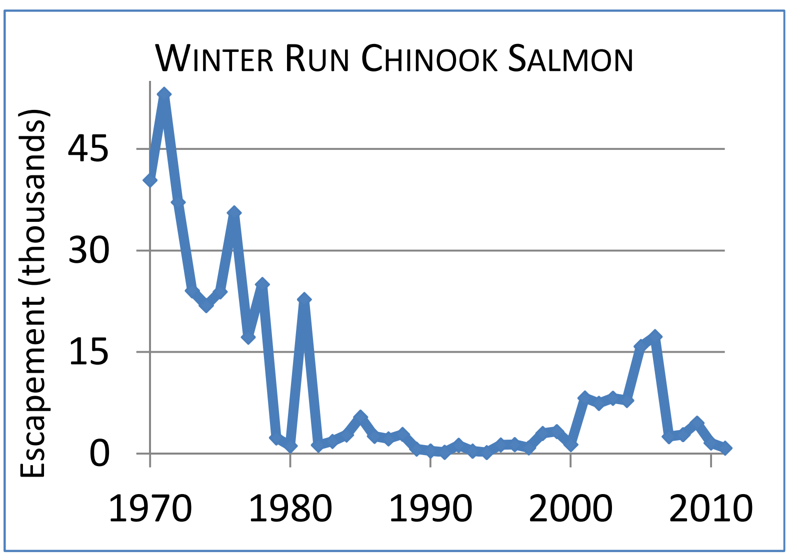

Fig. 1

[1] The cohort replacement rate is a measure of whether the population is increasing or decreasing. Because the majority of winter run spawners are three years old, the CRR is estimated by using the current brood year escapement divided by the escapement 3 years prior.

Fish and Game (DFG) estimated that adult winter run escapement in 2011 was only 824 spawners, including fish spawned at the hatchery. (NMFS 2012b: 1) This is the lowest level since 1994.

The National Marine Fisheries Service (NMFS) has suggested that the low 2011 escapement resulted from operations of Shasta Reservoir and dry conditions in 2008. (*See* NMFS 2011a: 20, 29-30). NMFS has also noted that the low abundance in recent years occurred despite the complete closure of the ocean fishery in 2008 and 2009, and very limited fishing season in 2010. (NMFS 2012: 30) Indeed, DFG concluded in a recent report that only 2 winter run Chinook salmon with coded wire tags were caught in the 2010 ocean fishery from brood years 2004, 2005, 2006, 2007, and 2008 (expanded count of 6). (Kormos et al 2012: 6 and Table 7)

Winter Run Chinook Salmon Population Estimates

Year	Population Estimate[a]	5-Year Moving Average of Population Estimate	Cohort Replacement Rate[b]	5-Year Moving Average of Cohort Replacement Rate	NMFS-Calculated Juvenile Production Estimate (JPE)[c]
1986	2,596				
1987	2,185				
1988	2,878				
1989	696		0.27		
1990	430	1,757	0.20		
1991	211	1,280	0.07		40,100
1992	1,240	1,091	1.78		273,100
1993	387	593	0.90	0.64	90,500
1994	186	491	0.88	0.77	74,500
1995	1,297	664	1.05	0.94	338,107
1996	1,337	889	3.45	1.61	165,069
1997	880	817	4.73	2.20	138,316
1998	2,992	1,338	2.31	2.48	454,792
1999	3,288	1,959	2.46	2.80	289,724
2000	1,352	1,970	1.54	2.90	370,221
2001	8,224	3,347	2.75	2.76	1,864,802
2002	7,441	4,659	2.26	2.26	2,136,747
2003	8,218	5,705	6.08	3.02	1,896,649
2004	7,869	6,621	0.96	2.72	881,719
2005	15,839	9,518	2.13	2.84	3,831,286
2006	17,296	11,333	2.10	2.71	3,739,050
2007	2,542	10,353	0.32	2.32	589,900
2008	2,830	9,275	0.18	1.14	617,783
2009	4,537	8,609	0.26	1.00	1,179,650
2010	1,596	5,760	0.63	0.70	332,012
2011	824[d]	2,466	0.29	0.34	NA[e]
median	2,364	2,218	1.05	2.26	412,507
mean[f]	3,814	4,113	1.63	1.90	
Last 10[g]	7,020	7,059	1.63	1.98	
Last 6[h]	4,938	7,966	0.63	1.37	

Figure 2 (reprinted from NMFS 2012a)

In 2010, NMFS issued a new biological opinion on the effect of the ocean salmon fishery on winter run salmon, and new measures to constrain take of winter run in the fishery were imposed. In 2011, NMFS released an analysis of the impacts of the fishery on winter run (O'Farrell 2011, Winship *et al* 2012) and its Winter Run Harvest Model to guide development of fishery measures to constrain impacts. NMFS concluded that ocean fishing is not adversely affecting winter run when populations are stable or increasing, but that measures were needed when the population was otherwise declining or at very low levels. (NMFS 2012c:1-2) The management strategy evaluation and life cycle model that it was based on found that, "*the most influential factors in winter-run population dynamics are related to variation in juvenile survival rates in the fresh water and marine environments (survival prior to age-2).*" (NMFS 2012c: 5) NMFS has also observed that "*Lindley et al. (2009) concluded that late-fall, winter and spring Chinook salmon in the Central Valley were not as strongly affected by recent changes in ocean conditions as the Sacramento River fall-run Chinook salmon*." (NMFS 2011: 30).

Since 2009, entrainment of winter run Chinook has been limited by the NMFS biological opinion, including OMR restrictions and an incidental take limit of entrainment at the CVP and SWP to less than 2% of the Juvenile Production Estimate (JPE). While entrainment has not exceeded this incidental take limit since 2009, incidental take of winter run exceeded 1% of the JPE in 2011. (NMFS 2011c: 50) In its presentation to the independent peer review panel organized by the Delta Science Program, NMFS examined the use of Smolt to Adult Ratios (SAR) to estimate the effect of juvenile incidental take on the abundance of adult winter run three years later, and estimated that the take in 2011 could be expected to reduce adult winter run populations in 3 years by 16-25%. (NMFS 2011d at 23; see Fig. 2)

Analysis of the population level effect of winter run losses at the Central Valley Project (CVP) and State Water Project (SWP) are ongoing.[2] However, in 2012 the independent peer review of the BDCP effects analysis cautioned against simply normalizing salvage to adult populations three years later:

> *A process to normalize observed salvage to mean population abundance of the species was described in order to account for some of the year to year variability in salvage associated with fish abundance.* ***Given the large and variable effect of survival at sea on adult salmon abundance, it seems that normalization of the juvenile salvage data to mean adult salmon abundance could introduce considerable error.*** *Was adult run size lagged back to the appropriate smolt year? Both normalized and non-normalized values of entrainment were provided, which is good.*

[Parker 2012: 41][3] (emphasis added)

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[2] Part of the debate over impacts focuses on the total number of fish impacted because run-identification of salvaged fishes is uncertain and because the number of fish salvaged is unquestionably only a small (though undetermined) fraction of the number of fish that are negatively impacted before they reach the SWP and CVP fish screening facilities.

[3] This peer review of the BDCP effects analysis was cited in the TBI et al submission for Workshop I:
[Parker, A., Simenstad, S., George, T., Monsen, N., Parker, T., Ruggerone, G., and Skalski, J. 2012. Bay Delta Conservation Plan (BDCP) Effects Analysis Phase 2 Partial Review, Review Panel Summary Report. Delta Science Program. Available at: http://deltacouncil.ca.gov/sites/default/files/documents/files/BDCP_Effects_Analysis_Review_Panel_Final_Report_061112.pdf]

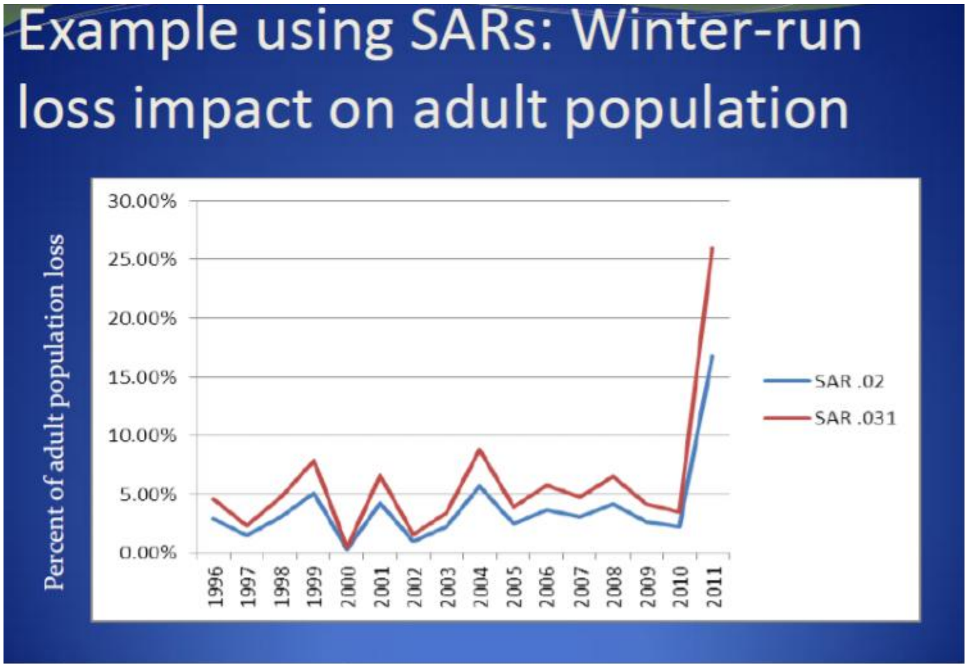

Fig. 3 (Reprinted from NMFS 2011c)

Furthermore, there is reason to believe that proportionate impacts of salmon entrainment that are expressed as a proportion of juvenile production would also significantly underestimate the population level effect of entrainment on Chinook salmon populations. DFG and NMFS have not updated the estimated survival to the Delta in the JPE calculation to account for recent acoustic tag data on survival to the Delta. (NMFS 2012b: 7) For instance, recent studies of late fall run Chinook salmon released in 2007-2007 with acoustic tags found that the average survival rate was only 3.9% for the migration from Battle Creek / upper Sacramento River release site to the ocean and that survival from the release site to the Delta was below 40% in all three years and was below 20% in 2007. (Michel 2010: 8 and Fig. 4)[4] Thus current estimates of entrainment at the pumps may substantially underestimate the fraction of the population that is taken, as well as the population level effects of this entrainment.

ii. Spring Run Chinook Salmon

Escapement of spring run Chinook salmon has been declining since 2005 in the Sacramento River basin and in most of the tributaries; since 2006, the cohort replacement rate has been less than 1 (indicating a negative growth rate and declining abundance) in the tributaries, and the CRR has been less than 1 in the basin since 2004. (NMFS 2012a: 26-27; *see* Fig. 4-5) Higher water temperatures and lower flows in 2007-2009 are generally associated with lower salmon abundance and may have contributed to recent declines.

The 2009 biological opinion does not establish an incidental take limit for spring run Chinook salmon based on observed salvage of spring run at the CVP/SWP. There currently is not a juvenile production estimate (JPE) for spring run, and there are difficulties in distinguishing spring and fall run fish in salvage. Currently, NMFS' biological opinion uses estimated salvage

[4] Michel 2010 is discussed in detail on page 20 of this submission.

of a few releases of late fall run hatchery salmon as surrogates for spring run take. (*See* NMFS 2011b: 51) There are substantial problems with this approach.

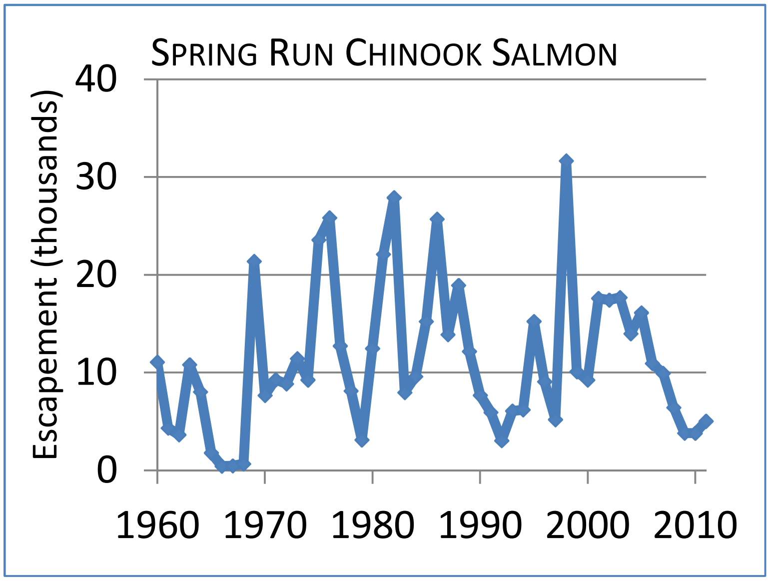

Fig. 4

Population numbers reveal only a part of the spring run's conservation status. Like winter run Chinook salmon, the spring run's geographic spawning range is severely restricted, making this unique species extremely susceptible to geographically isolated catastrophes (e.g. forest fires, mudslides, disease outbreaks). Geographic range restrictions represent a significant threat to fish populations (Rosenfield 2002) and to salmonids, in particular (McElhany et al 2000). Thus, current efforts to restore spawning populations of spring run Chinook salmon to watersheds in the San Joaquin River basin are considered essential to this species' persistence (NMFS 2008) in addition to the need to improve conditions and habitat availability in the Sacramento River basin waterways that support spring run spawning or could support it in the future.

Spring Run Chinook Salmon Abundance Estimates

Year	Sacramento River Basin Escapement Run Size[a]	FRFH Population	Tributary Populations	5-Year Moving Average of Tributary Population Estimate	Trib CRR[b]	5-Year Moving Average of Trib CRR	5-Year Moving Average of Basin Population Estimate	Basin CRR	5-Year Moving Average of Basin CRR
1986	25,696	1,433	24,263						
1987	13,888	1,213	12,675						
1988	18,933	6,833	12,100						
1989	12,163	5,078	7,085		0.29			0.47	
1990	7,683	1,893	5,790	12,383	0.46		15,673	0.55	
1991	5,926	4,303	1,623	7,855	0.13		11,719	0.31	
1992	3,044	1,497	1,547	5,629	0.22		9,550	0.25	
1993	6,076	4,672	1,404	3,490	0.24	0.27	6,978	0.79	0.48
1994	6,187	3,641	2,546	2,582	1.57	0.52	5,783	1.04	0.59
1995	15,238	5,414	9,824	3,389	6.35	1.70	7,294	5.01	1.48
1996	9,083	6,381	2,702	3,605	1.92	2.06	7,926	1.49	1.72
1997	5,193	3,653	1,540	3,603	0.60	2.14	8,355	0.84	1.84
1998	31,649	6,746	24,903	8,303	2.53	2.60	13,470	2.08	2.09
1999	10,100	3,731	6,369	9,068	2.36	2.75	14,253	1.11	2.11
2000	9,244	3,657	5,587	8,220	3.63	2.21	13,054	1.78	1.46
2001	17,598	4,135	13,463	10,372	0.54	1.93	14,757	0.56	1.27
2002	17,419	4,189	13,230	12,710	2.08	2.23	17,202	1.72	1.45
2003	17,691	8,662	9,029	9,536	1.62	2.04	14,410	1.91	1.42
2004	13,982	4,212	9,770	10,216	0.73	1.72	15,187	0.79	1.35
2005	16,126	1,774	14,352	11,969	1.08	1.21	16,563	0.93	1.18
2006	10,948	2,181	8,767	11,030	0.97	1.29	15,233	0.62	1.20
2007	9,974	2,674	7,300	9,844	0.75	1.03	13,744	0.71	0.99
2008	6,420	1,624	4,796	8,997	0.33	0.77	11,490	0.40	0.69
2009	3,801	989	2,812	7,605	0.32	0.69	9,454	0.35	0.60
2010	3,792	1,661	2,131	5,161	0.29	0.53	6,987	0.38	0.49
2011	4967	1,900	3,067	4,021	0.64	0.47	5,790	0.77	0.52
Median	10,037	3,655	6,727	8,262	0.73	1.70	12,386	0.79	1.27
Average[c]	11,647	3,621	8,026	7,708	1.29	1.48	11,585	1.08	1.21
Last 10[d]	11,156	3,091	8,065	9,224	0.85	1.27	12,802	0.83	1.02
Last 6[e]	6,650	1,838	4,812	7,776	0.55	0.80	10,450	0.54	0.75

Fig. 5 (Reprinted from NMFS 2012a)

iii. Central Valley Steelhead

There is currently no abundance estimate for Central Valley steelhead. However, according to NMFS, the available evidence suggests a decline in the population of wild steelhead since 2005:

> *The most recent status review of the California Central Valley steelhead DPS (NMFS 2011c) found that the status of the population appears to have worsened since the 2005 status review (Good et al. 2005), when it was considered to be in danger of extinction. Analysis of data from the Chipps Island monitoring program indicates that natural steelhead production has continued to decline and that hatchery origin fish represent an increasing fraction of the juvenile production in the Central Valley (see Figure 14). Since 1998, all hatchery produced steelhead in the Central Valley have been adipose fin clipped (ad-clipped). Since that time, the trawl data indicates that the proportion of ad-clip steelhead juveniles*

> *captured in the Chipps Island monitoring trawls has increased relative to wild juveniles, indicating a decline in natural production of juvenile steelhead. In recent years, the proportion of hatchery produced juvenile steelhead in the catch has exceeded 90% and in 2010 was 95% of the catch. Because hatchery releases have been fairly consistent through the years, this data suggests that the natural production of steelhead has been declining in the Central Valley*.

(NMFS 2012a: 33) NMFS also found that salvage at the CVP and SWP indicated a decline in natural production, and they found that while small numbers of wild steelhead consistently return to the Coleman fish hatchery (200-300 fish per year), the number of hatchery fish has fluctuated significantly and have declined in recent years. (NMFS 2012a: 33-34)

Entrainment and low survival rates through the Delta remain a concern for steelhead from the San Joaquin River basin, Sacramento River basin, and eastside tributaries. Although there is no population estimates for Central Valley steelhead, the 2009 NMFS biological opinion continues use of an incidental take limit of 3,000 wild steelhead that is not based on a measure of steelhead abundance. (NMFS 2011b at 53-54) Salvage of wild steelhead in 2011 (738) was lower than in 2010 (1,029), with the highest monthly salvage of wild steelhead observed in June 2011. (NMFS 2011b: 54, 68) The seasonal salvage for hatchery steelhead in 2011 was the lowest observed in the past 11 years. (NMFS 2011b: 54)

iv. <u>Fall Run Chinook Salmon</u>

The Pacific Fishery Management Council (PFMC) has forecast that the 2012 Sacramento River Index is 819,400 adult Central Valley Fall run Chinook salmon, with escapement estimated at 245,820 spawners. (PFMC 2012:9-10) This is higher than the SI forecast of 729,900 fish in 2011, but the forecast of escapement in 2011 was substantially higher than actual escapement. (PFMC 2012:9) The PFMC adopted revisions to the fishery management plan until the stock is rebuilt, which includes an annual management target of 122,000 natural and hatchery adult spawners at moderate abundance, and lower fishing rates at low abundance. (PFMC 2012:4).

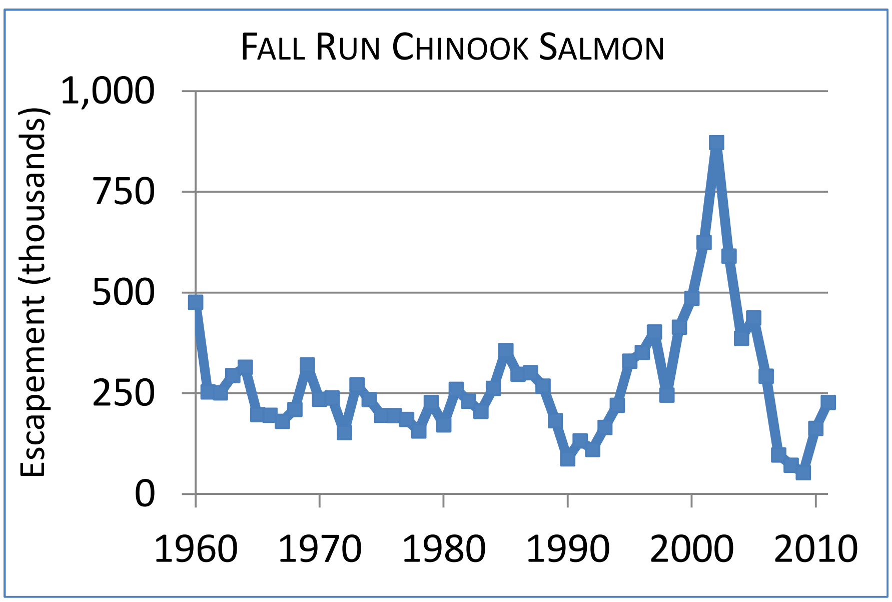

Fig. 6

The Central Valley Constant Fractional Marking Program (CFM) was initiated in 2007 to estimate in a statistically valid manner the relative contribution of hatchery production and to evaluate the various release strategies being employed in the Central Valley. Beginning with Brood

Year 2006 fall run Chinook, the program has marked and coded-wire tagged a minimum of 25 percent of releases from the Central Valley hatcheries each year. In 2012, biologists with the Department of Fish and Game released a report (Kormos et al (2012), *Recovery of Coded-Wire Tags from Chinook Salmon in California's Central Valley Escapement and Ocean Harvest in 2010*) which evaluates the 2010 CV fall, spring, winter and late fall run Chinook CWT recovery data in an attempt to answer the following four questions with this first essentially complete year of recovery data:

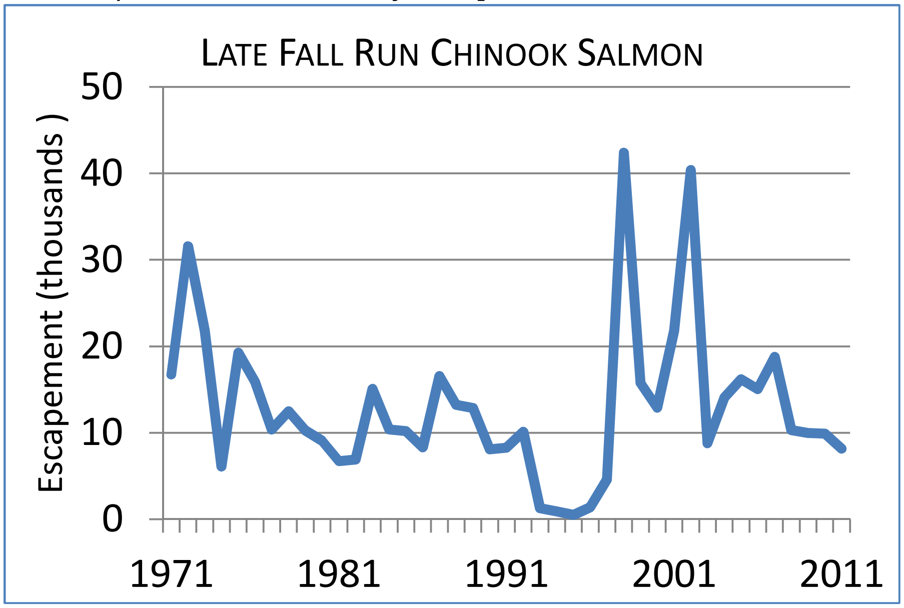

Fig. 7

1. What are the proportions of hatchery and natural-origin fish in spawning returns to CV hatcheries and natural areas, and in ocean harvest? Of the hatchery proportions, what proportions originated from in-basin versus out-of-basin CWT recoveries?
2. What are the relative recovery and stray rates for hatchery fish released in-basin versus salmon trucked to and released into the waters of the Carquinez Straits? The latter includes salmon acclimated in net pens that are pulled for several hours into San Pablo Bay before fish are released.
3. What are the relative recovery rates for fish acclimated in net pens and released in the bay versus salmon released directly into the waters of the Carquinez Straits?
4. What are the relative contribution rates of hatchery fish, by run and release type, to the ocean harvest?

General Recovery rates and age classes
Based on the findings presented in the report, during 2010, almost 27,000 CWTs were recovered from ad-clipped Chinook sampled in Central Valley natural area spawning surveys, at CV hatcheries, in CV river creel surveys, and in California ocean commercial and recreational fisheries. Almost all of the fall run Chinook CWTs recovered in the CV were tagged as part of the CFM program since most CV fish return at ages two, three, or four. Age five Chinook made up a very small fraction (0.01%) of the total CV fall run escapement in 2010.

24,838 valid CWTs recovered in the CV during 2010 were CV Chinook releases, with the majority originated from brood year 2006 through 2008. The specific breakdown of recoveries included more than 84% from fall run Chinook, followed by spring run (10%) and late fall run (6%). No Sacramento River winter run Chinook CWTs were recovered in 2010.

California ocean harvest recoveries in 2010 included 1846 of CV origin. Approximately 62% of all CWTs in the ocean harvest were fall run Chinook, followed by late fall run (30%), spring run (3%), and winter run (<1%). Only 2 winter run with CWTs (for an expanded count of 6) were caught in the ocean fishery in 2010.

Proportion of hatchery origin fish
Results indicate that the proportion of hatchery-origin fish on spawning grounds varied throughout the CV and by run. The lowest hatchery proportion (1%) was observed in the Butte Creek spring run Chinook mark-recapture survey, while the highest proportion (78%) was observed in the Feather River fall/spring run Chinook mark-recapture survey. The hatchery proportion of fall run Chinook returning to CV hatcheries ranged from 79% to 95%. Spring run Chinook return to FRH was 82% hatchery-origin fish whereas the late fall run return to CNFH approached 100% hatchery-origin. The majority of fish returning to spawn in the San Joaquin Basin and the Feather River were hatchery-origin, whereas the majority of fish returning to spawn in the Sacramento River were not.

Relative recovery and stray proportions for hatchery-origin Chinook released in-basin versus hatchery-origin Chinook trucked and released into the waters of the Carquinez Strait (includes Chinook salmon acclimated in net pens and released into San Pablo Bay).
Results on relative recovery and stray proportions of in basin vs. trucked and released hatchery-origin fish were limited due to “lack of consistency” and “problem releases” among CV hatcheries. As a result, the report only presents results from direct comparisons for in a limited number of release groups. Overall results indicate that, Chinook that were trucked and released directly into the waters of Carquinez Strait or acclimated in bay area net pens had higher relative recovery rates than their respective in-basin releases (often at a 2:1 ratio or more). These releases also had higher stray proportions than their paired in-basin counterparts.

Though based only on a single year of recovery data, and so not necessarily indicative of larger scale trends in population dynamics, results from this report reinforce other research findings pointing to a) the severe impact of low juvenile outmigration survival rates on subsequent abundance, b) the increase in straying resulting from the alternative strategy of ocean release, c) the severely imperiled condition of winter run stocks and need for immediate action to recover them, d) the dominance of hatchery origin returns in the CV. This program should provide very useful information to managers in the future.

B. IMPORTANCE OF SACRAMENTO INFLOWS INTO THE DELTA

The magnitude, timing, duration, and frequency of Delta inflows[5] from source streams has changed dramatically from historical condition, particularly during the winter and early spring months. These reductions in flow have diminished the Delta's ability to support the viability of anadromous resources that rely on the Delta for food, habitat and migration.

1. The importance of a natural flow regime

New Information Summary:

Flow is a critical determinant of native fish success. Altered flow regimes, due to water management facilities and operation, are a significant cause of native fish declines. In addition, altered flow regimes are a significant predictor of spring run Chinook extirpation.

> [Nislow, K. H. and J. D. Armstrong. 2011. Towards a life-history-based management framework for the effects of flow on juvenile salmonids in streams and rivers. Fisheries Management and Ecology. DOI: 10.1111/j.1365-2400.2011.00810.x]

Nislow and Armstrong review the state of science concerning the influence of flow regime on juvenile salmonids and their habitats. Their findings indicate that a key consideration in the stage-specific impacts of flow is the extent to which flow-related losses or gains during early developmental stages can be compensated by increased growth or survival later in juvenile life history. Their recommendations include targeting specific aspects of flow regimes critical to multiple life-history stages, which can then serve as a basis for interim flow prescriptions and subsequent adaptive management. Findings from their assessment point not only to the importance of flow as a critical determinant of juvenile salmon success, but to the need for a management approach that integrates flow management in the upper and lower watershed as well as other factors promoting increased growth and survival access to productive floodplain habitat.

> [Zeug, S.C. 2010. Predictors of Chinook Salmon Extirpation in California's Central Valley. Fisheries Management and Ecology 18: 61-71.]

Zeug 2010 examined the relative strength of predictors for probability of extirpation of Chinook salmon in Central Valley streams and found that altered flow regime, habitat loss, and migration barriers were all significant predictors for extirpation of spring run Chinook salmon.

> [Mount, J., W. Bennett, J. Durand, W. Fleenor, E. Hanak, J. Lund, and P. Moyle. 2012. Aquatic Ecosystem Stressors in the Sacramento–San Joaquin Delta. Public Policy Institute of California, San Francisco, CA. 24p. Available at: http://www.ppic.org/content/pubs/report/R_612JMR.pdf]

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[5] Because San Joaquin River inflows are being addressed in another Board proceeding, this submission focuses primarily on Sacramento River inflows.

This report synthesizes the stressors acting on the Delta into five key categories of like process and consequence relevant to management and decision-making:

> *1. **Discharges**: Land and water use activities that directly alter water quality in the greater Delta watershed by discharging various contaminants that degrade habitat, disrupt food webs, or cause direct harm to populations of native species.*
> *2. **Fisheries management**: Policies and activities that adversely affect populations of native species through harvest (commercial and sport) or hatcheries.*
> *3. **Flow regime change**: Alterations in flow characteristics due to water management facilities and operations, including volume, timing, hydraulics, sediment load, and temperatures.*
> *4. **Invasive species:** Alien (non-native) species that negatively affect native species by disrupting food webs, altering ecosystem function, introducing disease, or displacing native species.*
> *5. **Physical habitat alteration**: Land use activities that alter or eliminate physical habitat necessary to support native species, including upland, floodplain, riparian, open water/channel, and tidal marsh. (p. 8)*

Additionally, the report explains that none of these stressors is entirely independent of the others, with significant interactions amplifying or suppressing the negative effects each has on native populations. As an example, Mount et al 2012 points to water operations that reduce flow intensifying the effects of agricultural and urban discharges that, in turn, promote conditions favorable to invasive species that alter food webs and ecosystem functions.

> [Moyle, P., W. Bennett, J. Durand, W. Fleenor, B. Gray, E. Hanak, J. Lund, and J. Mount. 2012. Where the Wild Things Aren't: Making the Delta a Better Place for Native Species. Public Policy Institute of California, San Francisco, CA. 55p. Available at: http://www.ppic.org/content/pubs/report/R_612PMR.pdf]

Moyle et al 2012 attributes harm to native species living in or passing through the Delta as well as the degradation of water quality and habitat to key stressors working singly and in combination. These stressors include alteration of flows, channelization of waterways, discharge of pollutants, introduction of non-native species, and the diversions of water from the system. Their analysis identifies five core premises that have strong scientific support including that the most restrictive physical and biological constraints on the system include limits on the availability of fresh water, and the domination of the ecosystem by invasive species. The report recommends five key components of a strategy for recovery and reoperation of the delta, the first of which is that natural processes place limits on all water and land management goals.

> [Miller, J.A., A. Gray, and J. Merz. 2010. Quantifying the contribution of juvenile migratory phenotypes in a population of Chinook salmon *Oncorhynchus tshawytscha*. Marine Ecology Progress Series 408:227–240].

This study documented contributions of three different life-history types to subsequent adult populations but noted that management activity is often disproportionately focused on particular life history strategies (e.g. big or fast-growing juveniles). They note:

> *The contribution of all 3 migratory phenotypes to the adult population indicates that management and recovery efforts should focus on maintenance of life-history variation rather than the promotion of a particular phenotype.* (Miller et al. 2012: 227).

This finding reinforces the need to identify the full seasonal duration of flows that benefit different fish species as flows constrained to narrow durations and particular calendar dates tend to reduce migratory species' viability by eroding natural life history diversity (McElhaney 2000). Miller et al (2010) is also quite valuable in that it demonstrates the potential to measure the differential migration success of various life-history types post-hoc, using advances in otolith microchemistry; such an approach, when combined with current tagging and recapture studies should be expanded to provide a more comprehensive and accurate image of juvenile survival patterns prior to, during, and after their Delta migration.

2. **Sacramento River inflow targets and Delta outflow targets can be achieved without compromising the ability of the reservoirs to meet existing upstream temperature and flow requirements**

New Information Summary:

Water temperature plays a critical role in the life history of native fishes, particularly salmonids. Water temperature requirements vary substantially by life stage and actual water temperatures vary significantly both temporally and spatially. Furthermore, temperature requirements for individual life stages can vary depending on habitat quality, nutrition, and antecedent conditions. Healthy fish with a variety of habitat options are more likely to survive stressful temperatures than unhealthy fish.

The State Water Board's 2010 Report notes that additional analysis and modeling will be needed to determine how best to apply the percentage of unimpaired to allow Sacramento inflow requirements to be met while ensuring cold water temperature protections for fish in upstream tributaries at key times of the year. The 2010 Delta Flows Report also recognizes that inflow requirements should be proportionally allocated among the mainstem Sacramento and San Joaquin Rivers and their key tributaries. A proportional allocation of releases to meet downstream criteria among all source streams is necessary to ensure the flow-related connectivity between the upstream and Delta that is necessary for migratory species to complete their life cycles. A disproportionate allocation can lead to adverse flow and temperature conditions below facilities that are disproportionately responsible for meeting the criteria.

Increasing Delta outflow need not come at the expense of upstream reservoir storage, as recent modeling has demonstrated. We strongly recommend that that State Water Board build on the CALSIM modeling done in development of BDCP Alternative 8 to ensure adequate upstream cold water pool protections. As the State Water Board is well aware, one of the significant limitations of the CALSIM model is that it is difficult to model reservoir carryover requirements in the model and the model is driven to maximize CVP/SWP exports within available constraints. As discussed at the September 6, 2012 workshop, recent modeling that purports to show that increasing delta outflow will necessarily reduce upstream storage does not incorporate existing reservoir storage criteria, and it may assume continued levels of diversions that drive reservoir storage lower. CALSIM modeling of Alternative 8 in the BDCP process, which seeks to increase Delta outflow per the SWRCB's request, has demonstrated that increased Delta outflow can be accomplished without impairing upstream reservoir storage. The approach to modeling Alternative 8 in CALSIM should be further refined, in consultation with the fish and wildlife agencies, to take account of minimum releases needed to meet downstream temperature compliance points in the spring and summer months, and this revised modeling analysis should be applied to a broader range of alternative outflow objectives in this proceeding.

> [National Marine Fisheries Service. 2009. Biological Opinion on proposed long term operations of the Central valley Project and State Water Project. Available at: http://www.swr.noaa.gov/ocap/NMFS_Biological_and_Conference_Opinion_on_the_Long-Term_Operations_of_the_CVP_and_SWP.pdf]

The 2009 NMFS biological opinion (pp. 592-603) imposes reservoir carryover storage and release requirements on Shasta Reservoir for the protection of winter and spring run Chinook salmon. This biological opinion establishes performance measures that require a minimum of 2.2 million acre feet (MAF) of storage in Shasta Reservoir at the end of September in 87% of years, with end of April storage of 3.8 MAF in 82% of years, and end of September storage of 3.2 MAF in 40% of years. (NMFS 2009: 592) In years when end of September storage falls below these targets, the biological opinion establishes decision-making processes to establish reservoir release schedules for fall, spring and summer months. (NMFS 2009: 592-603)

The amount of cold water storage at the end of September limits the geographic extent of suitable spawning habitat for salmon in the Sacramento River (known as the temperature compliance point), and 2.2 MAF of storage at the end of September is generally necessary to provide sufficient cold water to establish the temperature compliance point at Balls Ferry of the following year in 80% of years.[6] (NMFS 2009: 593) The biological opinion establishes the following performance standards relating to the temperature compliance point:

- Meet Clear Creek Compliance point 95 percent of time
- Meet Balls Ferry Compliance point 85 percent of time
- Meet Jelly's Ferry Compliance point 40 percent of time
- Meet Bend Bridge Compliance point 15 percent of time

(NMFS 2009: 592)[7]

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[6] Balls Ferry is located approximately 23 miles upstream from the Red Bluff Diversion Dam. In Water Rights Order 90-5, the Board required the Bureau to maintain water temperatures below 56° F in the Sacramento River at Red Bluff Diversion Dam, except when factors beyond the control of the Bureau prevented meeting this temperature requirement. In recent years the temperature compliance point has been established at Balls Ferry or further upstream. (NMFS 2009 at 263)

[7] In its written summary submission to the State Water Board during the 2010 proceeding, NMFS provided a brief summary of storage objectives for Shasta Reservoir to protect listed salmon. Available online at: http://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/deltaflow/docs/exhibits/nmfs/nmfs_summary.pdf

The 2010 Public Trust Report briefly mentioned these requirements of the 2009 biological opinion and acknowledged that these reservoir storage requirements were (1) the minimum necessary to avoid jeopardy and were (2) constrained by water deliveries to senior water rights holders:

> *It is important to note that the flow protections described in the project description and RPA are the minimum flows necessary to avoid jeopardy. In addition, NMFS considered provision of water to senior water rights holders to be non-discretionary for purposes of the ESA as it applies to Section 7 consultation with the USBR, which constrained development of RPA Shasta storage actions and flow schedules.*

(SWRCB 2010: 23-24) (internal citations omitted)

The 2009 NMFS biological opinion also establishes minimum flow schedules and the following minimum temperature requirements:

River	Requirements	Reference
Clear Creek	60°F or lower at Igo gauge from June 1 to Sept 15 56°F or lower at Igo gauge from Sept 15 to Oct 31	Page 589
American River	65°F or lower at Watt Avenue Bridge from May 15 through October 31	Page 614
Stanislaus River	56°F or lower at Orange Blossom Bridge from 10/1 – 12/31 52°F or lower at Knights Landing and 56°F or lower at Orange Blossom Bridge from 1/1 – 5/31 55°F or lower at Orange Blossom Bridge from 1/1-5/31 65°F or lower at Orange Blossom Bridge from 6/1-9/30	Page 621

In addition, the biological opinion notes that non-flow measures can contribute to meeting these downstream water temperature requirements, including temperature control devices, temperature curtains, and other structural and operational modifications. (*See, e.g.,* NMFS 2009: 615-16)

However, it should be noted that these protections are principally designed to protect endangered and threatened runs; while these performance measures provide some protection for fall run Chinook salmon (which is not listed under the ESA), additional reservoir storage and downstream temperature requirements later in the year (October) should be considered to adequately protect fall run Chinook salmon in light of their different spawning and migration timing.

3. Relationship of increased flows to salmonid survival and migration

<u>New Information Summary:</u>

Several factors associated with increased flows influence salmonid migration rate and survival. In recent studies, migration rates of juvenile salmon were found to be fastest in the upper river region and slowest in the Delta. Additionally, survival of salmonid smolts migrating through the Sacramento River and through the Delta is extremely low, and a substantial number of the losses in the Delta can be attributed to the effects of the CVP and SWP operations.

> [Michel, C.J., A.J. Ammann, E.D. Chapman, P.T. Sandstrom, H.E. Fish, M.J. Thomas, G.P. Singer, S.T. Lindley, A.P. Klimley and R.B. MacFarlane. 2012. The effects of environmental factors on the migratory movement patterns of Sacramento River yearling late-fall run Chinook salmon (*Oncorhynchus tshawytscha*). Environmental Biology of Fishes. DOI: 10.1007/s10641-012-9990-8]

Michel et al (2012) examined the migration patterns of acoustically tagged late fall run Chinook salmon yearling smolts during their outmigration through California's Sacramento River and San Francisco Estuary in 2007–2009. Migration rates (14.3 $km \cdot day^{-1}$ (± 1.3 S.E.) to 23.5 $km \cdot day^{-1}$ (± 3.6 S.E.)) were similar to rates published for other West Coast yearling Chinook salmon smolt emigrations. Migration rates were fastest through the upper river regions, and slowest in the Delta. Additionally, the study modeled the influence of different reach specific and environmental factors on movement rate and population spreading. Results suggested that several factors associated with increased flows positively influenced migration rate including (in order of importance), river width to depth ratio, river flow, water turbidity, river flow to mean river flow ratio, and water velocity. Water temperature did not improve model fit, suggesting, among other things, the specific significance of flow as opposed to temperature in fish distribution and migration.

> [Michel, C. River and Estuarine Survival and Migration of Yearling Sacramento River Chinook Salmon (*Oncorhynchus Tshawytscha*) Smolts and the Influence of Environment. A thesis submitted in partial satisfaction of the requirements for the degree of Master of Arts in Ecology and Evolutionary Biology. December 2010.]

In this thesis, Michel summarized the results of three years of acoustic tagging results on salmon survival and migration rates. Michel (2010) concluded that the average survival rate for late fall run Chinook salmon released in 2007-2007 with acoustic tags was only 3.9% for the migration from Battle Creek / upper Sacramento River release site to the ocean and that survival from the release site to the Delta was below 40% in all three years and was below 20% in 2007. (Michel 2010 at 8 and Fig. 4). As the author notes, these three years were generally dry years with lower flows, so results may be different in higher flow years.

> [del Rosario, R. B., Y. J. Redler, and P. Brandes. 2010. Residence of Winter-Run Chinook Salmon in the Sacramento-San Joaquin Delta: The role of Sacramento River hydrology in driving juvenile abundance and migration patterns in the Delta. Abstract submitted to the CalNeva conference (manuscript in preparation). Available at: http://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/deltaflow/docs/exhibits/nmfs/nmfs_exh7.pdf]

This study found that Sacramento River flow at Freeport was a statistically significant predictor of the abundance of winter run Chinook salmon caught at Chipps Island, with higher flow during the migration period corresponding to higher abundance. Abundance of juveniles in the Chipps Island trawl was not found to be correlated with prior year's adult escapement in a statistically significant way:

> *The hydrology of the Sacramento River drives winter-run smolt abundance and emigration patterns in the Delta. The annual cumulative winter run smolt abundance is highly dependent on the amount of flows in the Sacramento River, such that higher volume of water flowing in the river during the winter run emigration period results in greater abundance of winter run smolts both entering the Delta at Knights Landing (multiple regression, R2=0.76, F=12.6, p=0.003), and subsequently exiting the Delta at Chipps Island (multiple regression, R2=0.93, F=53.7, p<0.0001; Figure 1). This positive correlation between smolt abundance, expressed as annual cumulative CPUE at either sampling location, is not significantly correlated with annual spawner abundance (p>0.25).*

(del Rosario et al 2010: 4) Thus increased Sacramento River inflow resulted in higher survival rates for winter run salmon.

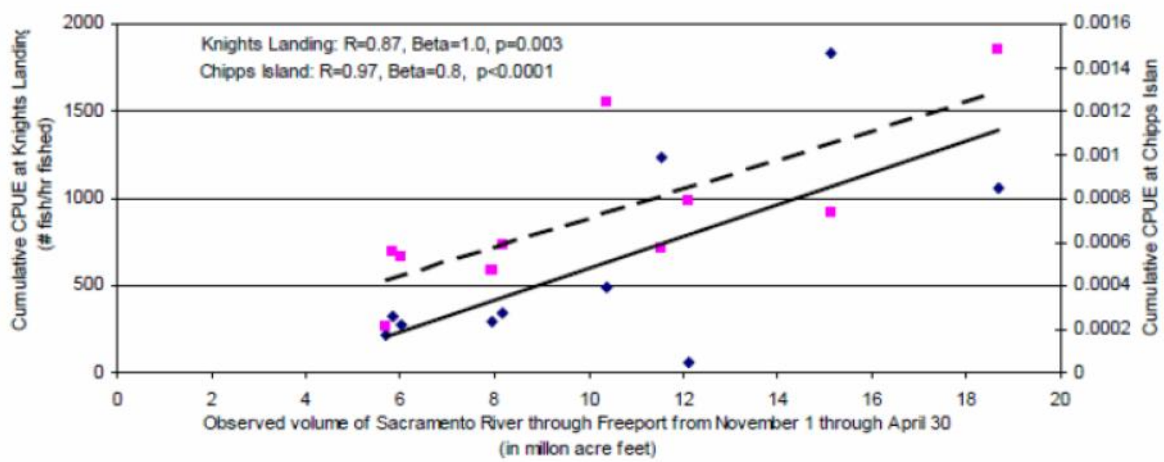

Fig. 8 Higher volume of flows during the winter run migration period results in greater abundance of winter run smolts entering the Delta at Knights Landing (diamonds, solid line) and subsequently exiting at Chipps Island (squares, dashed line), 1999-2008. (Reprinted from del Rosario et al 2010)

4. Importance of Inflow to Floodplains

Flood flows are essential for maintaining complex channel and floodplain features and, by inundating floodplains, provide essential spawning and rearing habitat for native fish. Pulse flows flush nutrients from inundated floodplains and create turbid habitat in the Delta improving growth and survival for native Delta species.

It is well established that juvenile Chinook salmon have faster growth rates on floodplains than in main-stem river channels (Sommer et al., 2001; Jeffres et al., 2008). Juvenile Chinook can enter and rear on floodplains during their downstream migration. Faster growth rates result in juveniles that are larger and have a higher likelihood of survival to adulthood. Although floodplain inundation provides important ecological benefits for salmon and the Delta generally, floodplain flows are relatively rare events along the Sacramento River due to levees and hydrologic alteration by dam. Loss of floodplain habitat has facilitated a less dynamic environment and one that is conducive to alien species that compete with juvenile salmon for prey in the limited habitat they do have or predate upon them. Due to the fact that many of these alien species are not capable of capitalizing on ephemeral floodplain innundation, the creation of additional floodplain habitat will serve the dual role of leveraging the evolutionary adaptations of central valley salmon to take advantage of the productivity of the flood pulse and reduce the concentration of predators and competitors in the existing habitat.

New Information Summary:

Information developed since 2010 reinforces the diverse benefits to salmonids of increased flows coupled with increased floodplain inundation and habitat availability. Specifically, new information emphasizes that juvenile salmon experience enhanced growth rates while utilizing floodplain habitat. Enhanced juvenile growth rates are correlated with higher juvenile survival rates. In addition, new information stresses the importance of floodplain habitat to combat the effects of climate change. (*See* climate change analysis below).

> [J. Katz. 2012. The Knaggs Ranch Experimental Agricultural Floodplain Pilot Study 2011-2012, Year One Overview. Available at http://baydeltaconservationplan.com/Libraries/Dynamic_Document_Library/YBFE_Planning_Team_%E2%80%93_Knaggs_Ranch_Pilot_Project_Year_One_Overview_6-13-12.sflb.ashx]

The Knaggs Ranch is a cooperative project between U.C. Davis and the Department of Water Resources (and supported by various other agencies, landowners and organizations) that proposes to incrementally develop a flood-neutral management approach in the Yolo Bypass that will benefit agriculture, fish, and waterfowl. The Pilot Study was initiated to evaluate growth of juvenile Chinook salmon in flooded agricultural fields. The main result of the study, high juvenile salmon growth rates while utilizing floodplain habitat, reinforces existing literature that indicates juveniles experience faster growth rates on floodplains. The report states:

> "*The remarkable growth rates and condition of juvenile Chinook reared on the Knaggs experimental agricultural floodplain illustrate the potential for managing seasonally inundated habitat for Chinook salmon. Managed agricultural floodplain habitat appears to produce bio-energetically favorable rearing conditions, when compared to conditions in the Sacramento River. Our initial results provide strong evidence that juvenile Chinook permitted to access seasonally inundated floodplain on Yolo By-pass experience 1) more rapid growth, 2) substantially improved body condition, 3) delayed out-migration timing, and 4) a superior out-migration route. These floodplain benefits will results in higher quality out-migrants and likely improved rates of return. It is our conclusion that gaining access to floodplain rearing for millions of naturally produced fish is the first step in re-establishing self-sustaining stocks of Chinook salmon in the Central Valley.*" (p.10)

[Nislow, K. H. and J. D. Armstrong. 2011. Towards a life-history-based management framework for the effects of flow on juvenile salmonids in streams and rivers. Fisheries Management and Ecology. DOI: 10.1111/j.1365-2400.2011.00810.x]

See Nislow 2011 summary above finding that there is need for a management approach that integrates flow management in the upper and lower watershed as well as other factors promoting increased growth, survival and access to productive floodplain habitat.

5. Importance of Inflow to Maintain Flow Corridors

As noted above, anadromous fish utilize the Delta for a number of critical functions including migrating (both upstream as adults and downstream as juveniles). Therefore, Delta inflow requirements must be sufficient to provide contiguous habitat between the upstream tributaries and the Delta. The State Water Board should consider whether its flow requirements will protect upmigrating adults coming into the Bay Delta Estuary in addition to helping juveniles migrate from their natal streams through the Estuary to the ocean. The State Water Board's 2010 Report identified the absence of a migratory corridor for returning adult salmon as an issue requiring attention.

New Information Summary:

Flow measures should be considered that both assist juveniles in route through the estuary and adults upmigrating through the Delta. Recent information notes that regulatory processes to date have not considered measures specific to assisting adult upmigration.

[Environmental Protection Agency. August 2012. Water Quality Challenges in the San Francisco Bay/Sacramento-San Joaquin Delta Estuary, EPA's Action Plan. Available at: http://www.epa.gov/sfbay-delta/pdfs/EPA-bayareaactionplan.]

[Environmental Protection Agency. February 2011. Water Quality Challenges in the San Francisco Bay/Sacramento-San Joaquin Delta Estuary, Unabridged Advance Notice of Proposed Rulemaking. Available at: http://www.epa.gov/sfbay-delta/pdfs/BayDeltaANPR-fr_unabridged.pdf]

In August 2012, after releasing its advanced notice of proposed rulemaking (ANPR) in February 2011, the United States Environmental Protection Agency (EPA) released its "Action Plan" for the Delta after assessing the effectiveness of current regulatory mechanisms in place to protect water quality in the Delta. Generally, EPA concludes that "…*Clean Water Act (CWA) programs currently are not adequately protecting aquatic resources of the Bay Delta Estuary*." The Action Plan proceeds to recommend various actions to address water quality concerns in the Delta.

Appendix 1 of the Action Plan specifically identifies the issue of fragmented fish migration corridors in the Delta. The Plan notes:

> *"Migratory fish rely on diverse habitats during different life stages and they require appropriate cues and connections to guide them to those habitats. Juvenile salmon use flow as the primary cue to maneuver from their spawning grounds through the rivers to the estuary. Salinity gradients and tidal action can then guide them to the ocean. Adult fish follow the unique chemical signature of their natal stream, although straying is common. Along these migratory paths, contaminants, high temperatures, low dissolved oxygen, physical barriers, and predators may interfere with migratory success. Thus, salmon management requires a watershed approach to ensure a connected and unblocked migratory corridor."* (EPA 2012: 26)

The EPA Plan notes that regulatory response to date has focused on helping juveniles make it through the estuary and to the ocean. Little attention has been paid to measures that may aid adults upmigrating through the Delta to their natal streams. The EPA notes:

> *"Migratory passage along the San Joaquin River is a beneficial use that may not be adequately protected. Outmigrating juveniles have some protection; adults migrating back to their natal streams have little protection. The absence of migratory cues for returning adult San Joaquin fish has not been comprehensively addressed in a regulatory framework.*
>
> *Although critical, the remediation of temperature and dissolved oxygen alone is unlikely to restore depleted salmon stocks unless water from the San Joaquin River and its tributaries supports a migratory corridor to and from the Estuary during both the season of adult upmigration and young outmigration."* (p.27)

Similarly, in the February 2011 ANPR, EPA found that,

> *Retrospective analysis of earlier sonic tagging data found significant impairment of adult salmon migration to San Joaquin tributaries when total state and federal exports exceeded three times the volume of water entering from the San Joaquin River at Vernalis."* (p. 58) (internal footnotes omitted)

The EPA analysis focuses on the San Joaquin River but clearly states that the problem is one that is central to the comprehensive Delta plan proceedings.

> "*EPA supports the work of the SWRCB to establish objectives for the San Joaquin River and the Delta that result in conditions which establish a migratory corridor for both juvenile and adult salmon*." (p.28**)**

The EPA urges the State Water Board to be mindful of the evolving science related to migratory corridors in the Delta such as sonic tagging studies.

In its BDCP Red Flag comments cited above, DFG echoed concerns about San Joaquin flows and Delta hydrodynamics during the adult migratory period:

> *The continuation of zero and [negative] SJR flows at Antioch is not protective of San Joaquin Basin fish. While the PP_ELT and PP_LLT [modeling of effects of the proposed project in the early and late long term periods] show an increase in OMR and SJR flows due to a reduction in south Delta exports, the continuation of low flows in August and September followed by 0 cfs in October and November and [negative] 2000 cfs in December is not protective. Positive SJR flows during this time are important and necessary to cue upstream adult migration, reduce straying, and to help address water quality concerns (e.g., DO and temperature).* (p.4)

C. <u>DELTA HYDRODYNAMICS & SALMON SURVIVAL</u>

New Information Summary:

Substantial research is underway to examine the effects of CVP/SWP exports, river flows, DCC gate operations, and other factors on the survival of salmon and steelhead through the Delta (and in upstream reaches). While data from 2006-2010 have been analyzed and published, results of studies and monitoring associated with operations in 2011 (a wet year with positive OMR for part of the spring) and 2012 (a below normal year with the Head of Old River Barrier (HORB) installed) are not yet available. However, recent studies continue to show very low survival rates through the Delta and show that current protections in D-1641 are inadequate to protect migrating salmonids.

> [Perry, R. W., P. L. Brandes, J. R. Burau, A. P. Klimley, B. MacFarlane, C. Michel, and J. R. Skalski. 2012. *Sensitivity of survival to migration routes used by juvenile Chinook salmon to negotiate the Sacramento-San Joaquin River Delta*. Environ. Biol. Fish. DOI 10.1007/s10641-012-9984-6]

In order to evaluate the relative benefit of management approaches that alter survival rates versus diverting fish away from low-survival routes and towards high-survival routes, Perry et al 2012 examine a 3-year data set of route-specific survival and movement of juvenile Chinook salmon in the Sacramento-San Joaquin Delta to quantify the sensitivity of survival to changes in migration routing at two major river junctions in the Sacramento River. Their results indicate that management actions that influence only migration routing were less effective at creating increased survival than actions that altered both migration routing and route-specific survival. They observed significant variation in survival rates among fish released between 2006 and 2009, with survival rates of less than 50% in every year except for the January 2007 release:

> *Although rankings of route-specific survival vary somewhat across release groups, one pattern remained consistent: survival probabilities for the Sacramento River were always greater than survival for migration routes through the interior Delta (via Georgiana Slough and the Delta Cross Channel; Fig. 3). (Perry et al 2012:7)*

The authors concluded that because overall survival rates are low in all routes, increasing survival through the Delta "*would require management actions that affect not only migration* *routing, but also survival within migration routes*." (p. 9) The authors also noted several limitations of this study. For instance, their analysis assumed that management actions only alter migration routing but not route-specific survival; however, as they note, changes in flow has been observed to change route-specific survival, and changes in the abundance of salmon in each route may change survival from predation. (p. 11) As a result, the authors cautioned that, "*absolute changes in survival should be interpreted with caution,*" but relative changes in survival between routes should provide stronger information for managers. (p. 11) Finally, because physical barriers change flow levels as well as migration routing, and nonphysical barriers only change migration routing, the authors caution that,

> *under the assumption of constant route-specific survival, non-physical barriers would realize only a fraction of the maximum possible increase in population survival. With respect to route-specific survival, physical barriers may yield a larger change in survival than non-physical barriers because physical barriers alter discharge and hydrodynamics of each migration route.*

(Perry et al 2012:11-12)

> [Singer, G., A. R. Hearn, E. D. Chapman, M. L. Peterson, P. E. LaCivita, W. N. Brostoff, A. Bremner, and A. P. Klimley. 2012. *Interannual variation of reach specific migratory success for Sacramento River hatchery yearling late-fall run Chinook salmon (Oncorhynchus tshawytscha) and steelhead trout (Oncorhynchus mykiss).* Environ Biol Fish DOI 10.1007/s10641-012-0037-y]

This paper presents results from studies of migratory survival of salmon and steelhead that were released in 2009 and 2010 with acoustic tags. The DCC gates remained closed during the releases in both years, and the study did not evaluate the effects of flow or exports on survival. The authors calculated route specific survival rates and the proportion of fish using each route, in order to estimate the proportion of fish surviving the migration through the Delta using each route. The authors observed that, "*Although overall migratory success to the Golden Gate was similar between 2009 and 2010, reach specific success was very different between years*." (p. 9) Overall survival from Elkhorn Landing (near Sacramento) to the Golden Gate Bridge was estimated as follows for each year and species:

	2009	2010
Salmon	19.2%	23.6%
Steelhead	14.6%	13.8%

(p. 9) However, as compared to 2009, in 2010 survival was lower through the Delta but higher through San Francisco Bay. (pp. 9-10) With respect to survival through the Delta, the authors noted that,

> *Success for both species in the Delta was above 60 % in 2009, yet dropped to below 45 % in 2010. Conversely, successful migration through San Francisco Bay was only around 50 % in 2009, yet increased to over 75 % in 2010. This apparent reversal in the relative success rates (which might be assumed to reflect mortality) may be counterintuitive, given that flows were higher in 2010, and*

> *increased flows are often associated with increased survival (Sims and Ossiander 1981). Survival of salmonid smolts in the Delta is positively correlated (r=0.95) with volume of flow and that the survival rate changed greatly as the flow changed. The survival was nearly 100 % when the flows were above 708 m3 s−1 (25 000 cfs), but less than 20 % when the flows were near 283 m3 s−1 (10 000 cfs) (Fischer et al. 1991). The paradox we observed may have resulted from indirect effects of climate and flow– the 2010 releases occurred in March, 1 month later than in 2009.*

(pp. 10-11) Consistent with Perry et al 2010, the authors concluded that survival rates through the East Delta were lower than other routes, even with the DCC closed:

> *It has been suggested that fish entrained in the East Delta have lower survival rates than other routes (Perry et al. 2010), although it is important to note that Perry defined "survival" as migration to Chipps Island. This was consistent with our results - throughout the duration of our study, fish migrating through the East Delta had lower overall survival than fish choosing either the West Delta or the mainstem Sacramento River, with the exception of West Delta steelhead in 2009 (Fig. 6).*

(p. 15) Although their study did not directly examine why survival was lower in the East Delta routes, the authors note that migratory survival is generally inversely related to migratory distance, and note that fish entrained into the East Delta have a longer route to the ocean and potentially encounter the CVP and SWP pumps, and they also noted that,

> *Additionally, the Operations Criteria and Plan (OCAP) Biological Assessment (BA) (USBR 2008) contains regressions of monthly steelhead salvage at the Central Valley Project and State Water Project pumping facilities, which shows a significant relationship between number of steelhead salvaged and the amount of water exported during the months of January through May, the same time that our tagged fish where in the Sacramento River Watershed. Our study suggests that entrainment in the east delta was negatively correlated with success to the ocean.*

(p. 15)

Table 2 Number and proportion of fish that used each route though the Delta, and their success to the Golden Gate Bridge

		Chinook		Steelhead	
		2009	2010	2009	2010
West Delta	# of fish	93	137	72	60
	Prop utilizing route	0.21	0.316	0.231	0.288
	# to Golden Gate	28	42	7	18
	Prop. Success to ocean	0.30	0.31	0.10	0.30
East Delta	# of fish	68	62	53	59
	Prop utilizing route	0.154	0.143	0.17	0.188
	# to Golden Gate	6	10	10	6
	Prop. Success to ocean	0.09	0.16	0.19	0.10
Mainstem	# of fish	281	234	187	109
	Prop utilizing route	0.636	0.54	0.599	0.524
	# to Golden Gate	55	61	46	36
	Prop. Success to ocean	0.20	0.26	0.25	0.33
Total fish in delta		442	433	312	208

Fig. 9 (Reprinted from Singer et al 2012)

[Perry, R. W., J. R. Skalski, P. L. Brandes, P. T. Sandstrom, A.P. Klimley, A. Ammann, and B. MacFarlane. 2010. *Estimating Survival and Migration Route Probabilities of Juvenile Chinook Salmon in the Sacramento–San Joaquin River Delta*. North American Journal of Fisheries Management 30:142–156. DOI: 10.1577/M08-200.1]

This study reports results of acoustic tag survival studies for salmon released in migration years 2007-2009. The overall survival through the Delta (the fraction surviving through all routes) averaged less than 33% for migration years 2007–2009. Survival was substantially lower for fish that were entrained into the interior Delta, including fish entrained through the Delta Cross Channel Gates; salmon migrating along the Sacramento River were between 1.5 and 6.6 times more likely to reach Chipps Island. The study showed that low flows in the Sacramento River (as well as opening the Delta Cross Channel gates) increase the chances of fish being entrained into the interior Delta, with lower survival rates.

[National Research Council. 2012. Sustainable water and environmental management in the California Bay-Delta. National Research Council. The National Academies Press, Washington, DC. Available at: https://download.nap.edu/catalog.php?record_id=13394]

In their 2012 report, the National Academy of Sciences concluded that, "*The committee accepts the conclusion that pump operations pose a risk to juvenile salmonids. The survival of salmonid smolts migrating through the Delta is low. Several studies make this point.*" (p. 81) For instance, the NAS report reviewed Michel 2010 and found it supported the conclusion that survival to the Bay was, "*an order of magnitude less than that typically reported for yearling Chinook smolts migrating past eight dams in the Snake Columbia River system*," and that 20-30% of smolts died in the Delta and that, "*[t]hese losses are substantive and are at least in part attributable to pump operations that alter current patterns into and through the channel complex, drawing smolts into* *the interior waterways and toward the pumps*." (p. 81) The committee also acknowledged that salmon survival from the San Joaquin River in recent years has been estimated to be between 5 and 8 percent. (p. 81) But the committee warned that "*delta-specific management actions may not yield the large survival benefits as some might expect. Migrating smolts incur substantial levels of mortality outside of passage through the Delta including mortality directly and indirectly associated with SWP and CVP pump operations*." (p. 81)

> [Cavallo, B., J. Merz, and J. Setka. 2012. Effects of predator and flow manipulation on Chinook salmon (*Oncorhynchus tshawytscha*) survival in an imperiled estuary. Environ. Biol. Fish. DOI 10.1007/s10641-012-9993-5]

Cavallo et al (2012) examined the effects of predator control and increased flow (resulting from opening the Delta Cross Channel gates) on survival rates for juvenile salmon migrating through the Delta from the Mokelume River. Their evaluation of removal of non-native, piscivorous fish found that migratory salmon survival after predator reduction improved in half of the treatments (there were significant improvements in survival after the first predator reduction treatment (from <0.80 to >0.99) but there was no apparent improvement in survival as a result of the second predator reduction treatment (survival decreased to pre-impact levels)). The authors suggested that daily (rather than weekly) predator removals, or removals across a broader geographic area, may be necessary to see any benefits for salmon survival. They also acknowledged that, "*we cannot rule out that observed changes in impact reach salmon survival occurred for reasons other than reduced predation pressure*." (p. 9) Increased flow and decreased tidal effect, however, resulted in decreased emigration time and increased survival in juvenile salmon. These results demonstrate that habitat manipulation through increased flow in the Delta tidal transition zone can be an effective approach to enhance salmon survival.

D. <u>RECENT SALMONID LIFE CYCLE MODELS</u>

New Information Summary

NMFS is developing a new life cycle model for Central Valley salmon runs. The 2011 independent peer review panel found that no existing life cycle models (including the IOS model) were adequate for evaluating the effects of the RPAs, and instead recommended that NMFS develop its own model. New life cycle models should help inform future management actions to restore listed salmon and steelhead runs.

> [Rose, K., J. Anderson, M. McClure, and G. Ruggerone. June 14, 2011. *Salmonid Integrated Life Cycle Models Workshop: Report of the Independent Workshop Panel. Delta Science Program*. Available at: http://deltacouncil.ca.gov/sites/default/files/documents/files/Salmonid_ILCM_workshop_final_report.pdf]

This report summarized an independent panel review of existing salmon life cycle models, including the SALMOD, Shiraz, IOS, Delta Passage submodel, and OBAN models. The panel recommended that instead of using any of these existing models, NMFS should develop its own life cycle model, stating that:

> *The Panel recommends that NMFS develop a model (or models) from the beginning. NMFS should use the existing models as guidance and the foundation, but should not try to modify one of the existing models to use for evaluating water management and the RPA actions. None of the models reviewed was completely appropriate alone for the needed life cycle model. Furthermore, none of the codes from the existing models, including SLAM, which is a general model, should be used for the NMFS model.*

(Rose 2011:8; see pp. 12-13, 9, 18). In addition, the panel identified concerns with using several of the models:

> *Several of the models presented at the workshop (IOS, Shiraz, SALMOD, and OBAN) use the same approach of representing life stage survivals as Beverton-Holt (or Ricker) like functions (density-dependence). Environmental covariates (e.g., water temperature, flow) are then added to these functions based on correlation analyses. The Panel had several cautions about using this approach for a model designed to address water management and RPA actions.*

(Rose 2011: 13-14). The panel also suggested that NMFS' life cycle model should explicitly consider the impacts of degraded freshwater habitat and competition with hatchery fish as a source of density dependence, even at low abundances (p. 16), and emphasized that the life cycle model should be developed to include life history variation and spatial distribution elements of the Viable Salmonid Population frameworks, instead of only modeling abundance (p. 16-17).

> [Zeug, S., P. S. Bergman, B. J. Cavallo, and K. S. Jones. 2012. *Application of a Life Cycle Simulation Model to Evaluate Impacts of Water Management and Conservation Actions on an Endangered Population of Chinook Salmon*. Environ. Model Assess. DOI 10.1007/s10666-012-9306-6]

This paper describes sensitivity analysis of the IOS life cycle model for winter run Chinook salmon. The paper reports that, "Delta survival, water year, and egg mortality were significant drivers of variability in age 3 escapement" (p. 10) and that "harvest may have a profound effect on salmon population dynamics" (p. 10). The model predicted that escapement was very sensitive to increases in water temperature, with a 10% increase in temperature producing a 95.7% reduction in escapement, with escapement less sensitive to changes in flow and not sensitive to changes in exports or ocean conditions. (p. 11) However, the authors also acknowledged some of the limitations of the model, for instance stating that:

> *several of the relationships in the IOS model are based on limited data that influence the estimate of input parameters and the form of uncertainty distributions associated with those estimates. For example, river migration survival has been hypothesized to be influenced by flow,* ***yet survival during the river migration stage is not influenced by flow in our model because the values we used to inform the relationship were***

> ***taken from a field study conducted over three low-flow years.*** (p. 11) (footnotes omitted) (emphasis added).

They also acknowledged that, "*The lack of significant changes in escapement with a 10% change in flow, exports and ocean conditions may reflect the type of data used to parameterize these relationships*." (p. 11) The model used uniform random variables for ocean conditions and smolt to age 2 survival, which the authors indicated could significantly affect model output.

E. CLIMATE CHANGE CONSIDERATIONS

The State Water Board's 2010 Flow Report did not specifically analyze the projected impacts of climate change on native species or their habitat. The report does suggest that the current criteria may not be appropriate in the future given the uncertainty associated with climate change effects.

> "*The numeric criteria are all short term criteria that are only appropriate for the current physical system and climate. There is uncertainty in these criteria even for the current physical system and climate, and therefore for the short term. Long term numeric criteria, beyond five years, for example, and assuming a modified physical system, are highly speculative. Only the underlying principles for the proposed numeric criteria and the other measures are advanced as long term determinations*." (p.128)

The 2010 Flow Report appears to anticipate that climate change will be considered in the context of an adaptive management program.

New Information Summary:

Recent literature finds that many native California fish, including salmonids, are vulnerable to extirpation in the near future. Climate change effects enhance that vulnerability. The effects of climate change can be ameliorated by restoring floodplain connectivity and stream flow regimes, re-aggrading incised channels and developing regional management plans that focus on restoring native fish.

> [Beechie, T., H. Imaki, J. Greene, A. Wade, H. Wu, G. Pess, P. Roni, J. Kimball, J. Stanford, P. Kiffney and N. Mantua. 2012. Restoring salmon habitat for a changing climate. River Research and Applications. DOI: 10.1002/rra.2590]

Beechie et al (2012) developed a decision support process for adapting salmon recovery plans that incorporates (1) local habitat factors limiting salmon recovery, (2) scenarios of climate change effects on stream flow and temperature, (3) the ability of restoration actions to ameliorate climate change effects, and (4) the ability of restoration actions to increase habitat diversity and salmon population resilience. Through the application of this process to systems in the pacific northwest, their findings indicated that restoring floodplain connectivity, restoring stream flow regimes, and re-aggrading incised channels were the restoration actions most likely most likely to ameliorate stream flow and temperature changes and increase habitat diversity and population resilience. Additionally, the potential benefits associated with this suite of actions stood in contrast with in-stream rehabilitation actions, which they found were unlikely to ameliorate climate change effects.

> [United States Environmental Protection Agency. August 2012. Water Quality Challenges in the San Francisco Bay/Sacramento-San Joaquin Delta Estuary, EPA's Action Plan. Available at: http://www.epa.gov/sfbay-delta/pdfs/EPA-bayareaactionplan.]

As noted above, in August 2012, the EPA released its "Action Plan" for the Delta after assessing the effectiveness of current regulatory mechanisms in place to protect water quality in the Delta. Generally, EPA concludes that "…Clean Water Act (CWA) programs currently are not adequately protecting aquatic resources of the Bay Delta Estuary." (p.2) The Action Plan notes that adverse effects from the loss of functional floodplain habitat in the Delta are likely to be exacerbated by climate change.

> *"Beginning in the 1850s, settlers diked, drained, and converted the floodplains, riparian corridors, and wetlands of the Bay Delta watershed into farms, cities and suburbs. (See Figure 3) A diversity of unique natural communities were destroyed and displaced, along with the fish and wildlife they supported. The losses include approximately 313,000 acres of wetlands in the Delta, 637,000 acres of riparian forest along the Sacramento River, and 329,000 acres of riparian forest along the San Joaquin River. Throughout the watershed, levees were built near creeks and rivers, thereby disconnecting them from their historical floodplains. Consequently, the floodplains that once provided valuable rearing and foraging habitat for fishes when seasonally inundated were converted to other uses. In addition, the loss of wetlands, floodplains, and riparian corridors greatly diminished the ability of these areas to accommodate flooding and recharge groundwater aquifers. Anticipated effects of climate change – including rising sea levels and more intense rainfall events – may exacerbate the ecological and flood control problems associated with the conversion of these aquatic habitats."*(p.100)

This excerpt highlights the importance of floodplain habitat in the Delta to ameliorate the effects of climate change.

> [BDCP "Red Flag" Documents [California Department of Fish and Game; US Fish and Wildlife Service; and National Marine Fisheries Service. April 2012 BDCP EA (Ch. 5) Staff "Red Flag" Review Comprehensive List. Available at: http://baydeltaconservationplan.com/Libraries/Dynamic_Document_Library/Effects_Analysis__Fish_Agency_Red_Flag_Comments_and_Responses_4-25-12.sflb.ashx]

In their review of the February 2012 BDCP draft effects analysis, the state and federal fish and wildlife agencies observed significant adverse effects from the combination of CVP/SWP operations under BDCP and climate change, which could lead to the extinction of several salmon runs. For instance, the National Marine Fisheries Service wrote that,

> *The analysis indicates that the cumulative effects of climate change along with the impacts of the PP may result in the extirpation of mainstem Sacramento River populations of spring-run and winter-run Chinook salmon over the term of the permit.*

(p.28) Similarly, DFG found that:

> *Winter-run redd dewatering and lower weighted usable spawning habitat in the Sacramento River under the preliminary proposal is not acceptable. This would lead to a significant decline in the population (as estimated by the JPE).*
>
> *Spring-run egg mortality in the mainstem of the Sacramento River is near 100 percent during dry and critical dry years. This type of egg mortality could lead to the extirpation of spring-run Chinook salmon from the mainstem of the Sacramento River during one drought cycle.*

(p. 3-4) Because of these concerns, NMFS recommended that operational criteria be developed that would ensure the protection of suitable habitat in the upper Sacramento River.

> [Moyle, P.B., R.M. Quinones, J. Kiernan. 2012. Effects of Climate Change on Inland Fishes of California: With Emphasis on the San Francisco Estuary Region. California Energy Commission White Paper. Available at: http://uc-ciee.org/downloads/Effects%20of%20Climate%20Change%20on%20the%20Inland%20Fishes%20of%20California.pd]

In 2003, the California Energy Commission created its Climate Change Center to document climate change research relevant to the state. The Center commissioned a report to analyze the effects of climate change on inland fishes in California. The report notes that anadromous fish will be especially affected by climate change:

> *"California's native inland fish fauna is in steep decline, a pattern which is reflected in the status of fishes native to streams flowing into the San Francisco Estuary and in the estuary itself. Climate change will further reduce the distribution and abundance of these mostly endemic fishes and expand the distribution and abundance of alien fish species. The decline and likely extinction of many native fishes reflects dramatic shifts in the state's aquatic ecosystems; shifts which are being accelerated by climate change. Fishes requiring cold water, such as salmon and trout, will especially suffer from climate change impacts of warmer water and reduced summer flows. Additionally, desirable species living in the San Francisco Estuary and the lower reaches of its streams will have to contend with the effects of rising sea level along with changes in flows and temperature."* (p.5)

The report includes both dams and alien species among the top factors negatively affecting native species. The report notes that many native aquatic species will disappear in the future without regional management strategies in place that incorporate measures for, among other things, obtaining and preserving habitat that can act as a climate change refugia and managing coldwater pools in reservoirs to favor native fish.

II. RECOMMENDED CHANGES TO THE BAY-DELTA WATER QUALITY CONTROL PLAN AND PROGRAM OF IMPLEMENTATION

A. Recommendations for New and Revised Objectives in the Bay Delta Water Quality Control Plan

We recommend that the State Water Board consider the following measures in its update of the water quality control plan, consistent with the potential objectives identified in the 2009 staff report:

1. Sacramento River Inflow and Delta Outflow Objectives: Increase winter/spring inflow and outflow objectives to improve migratory survival of juvenile salmonids into and through the Delta sufficient to achieve the SWRCB's narrative salmon doubling objective and other specific targets to restore and maintain natural, self-sustaining, and ecologically and commercially viable anadromous fish populations (see below). Releases from upstream sources should be made proportionally to each stream and watershed as a fraction of unimpaired flow to preserve ecological connectivity between the Delta and upstream watersheds and to avoid concentrating impacts on a subset of source areas.

2. Floodplain Habitat Flow Objectives: Establish Sacramento River inflow and structural modifications objectives such that flows from the Sacramento River inundate floodplains for 15-120 days between December and May every year or twice in every three years.

3. Reverse Flow Objectives/Export:Inflow Objectives: Establish objectives limiting reverse flows in Old and Middle River (OMR) and/or other restrictions on hydrodynamics and exports (e.g., I:E ratios) that reduce juvenile entrainment and improve migratory survival in the winter and spring months in order to achieve specific survival and other targets (see below). In addition, establish objectives that provide adequate migratory corridors through the Delta for both juveniles and adults, including pulse flow releases and restrictions on exports during fall months to allow for successful upmigration of adults, particularly those coming into the San Joaquin River.

4. Maintain Adequate Upstream Temperature Conditions: Build on the CALSIM modeling done for BDCP Alternative 8 to ensure that upstream reservoirs maintain adequate end of April and end of September storage (cold water pools) and release sufficient flows to maintain temperature compliance points downstream from these reservoirs while meeting Delta flow objectives.

B. Recommendations for the Program of Implementation to Address Climate Change and Changed Circumstances

We provide the following recommendations to account for climate change and changed circumstances:

(1) Develop and implement a robust adaptive management program tied to clearly defined biological outcome metrics that clearly define success.
(2) Develop and implement protective flow objectives that will enhance species' natural resiliency to habitat disturbances (e.g., through increased spatial distribution of populations) and increase diversity of life history stages.

We recommend that the State Water Board develop a robust adaptive management program that establishes targets and defines desired outcomes for public trust values and beneficial uses of the Bay Delta system that are specific, measureable, achievable and relevant to the particular goals that characterize the plan's overarching purpose (protecting the public trust values and beneficial uses of the Delta ecosystem) and timebound (S.M.A.R.T.), and evaluates the performance of the WQCP objectives over time toward achieving these targets. The State Water Board should establish quantitative targets when possible, such as survival, abundance, and spatial distribution metrics, as opposed to narrative outcomes. For instance, outcomes for Chinook salmon should include metrics identifying quantifiable improvements in the survival of outmigrating juveniles and metrics identifying increased abundance targets sufficient to meet the State Water Board's narrative salmon doubling objectives and other targets for restoring and maintaining natural, self-sustaining, and ecologically and commercially viable anadromous fish populations. For a more detailed description of this process, please see the TBI et al August 17, 2012 submission for Workshop 1. The flow objectives and adaptive management program should be sufficient to achieve greater diversity of life history strategies for salmonid populations and enhance the resiliency of those populations. In other words, the State Water Board should identify objectives that will increase and sustain salmonid life history diversity to ensure a more resilient population that is better able to respond to future climatic disturbances.

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Additional Scientific Information Related to Pelagic Fish Species, Recommended Changes to the Bay-Delta Water Quality Control Plan, and Recommendations to Address Scientific Uncertainty and Changing Circumstances

Workshop 2: Bay-Delta Fishery Resources

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The Bay Institute
Natural Resources Defense Council

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I. Response to Question 1: Additional Scientific Information and Recommended Changes to the Bay-Delta Water Quality Control Plan Regarding Pelagic Fish Species

In order to protect pelagic fishery resources,[1] the State Board's 2010 Delta Flow Report identified more flow, of a more natural flow pattern, including increased winter/spring Delta inflows and outflow, limitations on reverse Old & Middle River (OMR) flows and exports, and increased fall Delta outflows. New scientific information developed since 2010 largely confirm these recommendations and the Board's conclusion that "*the best available science suggests that current flows are insufficient to protect public trust resources*" (SWRCB 2010:2). For longfin smelt and other estuarine species, spring outflow continues to be the driver of abundance, and, as demonstrated by the high entrainment rates seen in 2012, additional restrictions to reduce and limit entrainment of adult, larval, and juvenile longfin smelt in the winter and spring months are necessary. For Delta smelt, substantial scientific information shows the necessity of limiting entrainment through OMR restrictions and the necessity and benefits of providing increased fall outflows. Additional evidence suggests that Sacramento splittail and other fishes benefit from increased flow rates on inundated floodplains, but that limitations on entrainment are also important (2011 was a record year for entrainment of Sacramento splittail (~9,000,000 individuals were salvaged at the SWP/CVP facility). And new scientific information since 2010 continues to show strong relationships between Delta outflow and the abundance of zooplankton and copepods that comprise much of the prey base for these species (diversions and barriers also play a role in altering and reducing available food supply).

Freshwater flow continues to be the "master variable" driving the health and productivity of the San Francisco Bay-Delta estuary, other estuarine systems, and pelagic fisheries. In our submission for Workshop 1 (cited here as TBI et al 2012), and in our prior submissions to the Board's 2010 proceedings (TBI et al. 2010), we:

- Identified the population status of pelagic fish species in the Delta;
- Documented the substantial declines in seasonal outflow due to increased diversions, particularly in recent decades by the State and Federal water projects;
- Documented the scientific basis demonstrating that improved outflow during the winter/spring, and fall (and possibly late summer) months is necessary to protect and restore pelagic fisheries;
- Discussed new science relating to other stressors on pelagic fisheries and the health of the estuary, including scientific information demonstrating that flow and physical habitat interact but are not interchangeable; and,
- Provided detailed information to guide the Board's development of adaptive management in the program of implementation.

[1] Pelagic fishes are those that spend all or most of their lives in open, flat water. For our purposes here, "pelagic" fishes include native smelt species (longfin and Delta), starry flounder, and striped bass as well as zooplankton and the foodwebs for these species. For simplicity (to avoid creating another category) we also include in this group Sacramento splittail, which are much more associated with shallow water habitats on the margin of larger water bodies.

In this submission we briefly summarize those prior findings and focus on issues relating to entrainment and in-Delta flows (including OMR flows), which were not previously addressed in Workshop 1. Based on the available scientific information, we conclude that these new studies and publications support the Board's findings in the 2010 Delta Flow Report, including:

(1) Existing flows are inadequate to protect Public Trust resources;
(2) Winter/Spring outflows should be substantially increased to levels that are sufficient to achieving restored population viability and ecosystem function, and should be implemented as a percentage of unimpaired flows occurring in a narrow averaging period;
(3) Fall (and possibly late summer) outflows should be increased to provide sufficient habitat, especially following wetter year types;
(4) Restrictions are needed to limit entrainment and poor survival in the Delta, beyond those described in the federal biological opinions and the State Incidental Take Permit for longfin smelt, including OMR flows and restrictions on exports; and
(5) Non-flow measures (such as physical habitat) interact with flow, but are not interchangeable and cannot substitute for flow.

A. FRESHWATER FLOW IS A "MASTER VARIABLE"[2] DRIVING THE HEALTH AND PRODUCTIVITY OF THE SAN FRANCISCO BAY-DELTA AND OTHER ESTUARINE ECOSYSTEMS.

In the hearing process that culminated in the Delta Flow Report (SWRCB 2010), and again in Workshop 1, the Board heard overwhelming scientific evidence that declines in freshwater flow into, through, and out of the Delta, resulting from increasingly intrusive human water management activities (diversions and storage), play a central role in the both the long-term and shorter-term declines in our once-abundant fisheries.[3] After reviewing this wealth of evidence, the State Board found:

> *The best available science suggests that current flows are insufficient to protect public trust resources.* [SWRCB 2010:2].

In its closing comments in the 2010 proceeding, the U.S. Department of Interior concluded that:[4]

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[2] I interpret this term, coined by Poff et al. 1997, to mean that freshwater flow drives or strongly interacts with a wide variety of ecosystem variables and processes of importance to the physical characteristics and biota of river and estuarine systems. I interpret testimony during workshop #1 of this proceeding, from Dr. Cliff Dahm and Dr. Ted Sommer (DWR) to be completely consistent with this meaning of the term.

[3] These findings do not diminish the imperative to address other long-standing or emerging stressors to the Bay-Delta ecosystem, including water quality issues, sediment toxins such as selenium, and habitat loss; however, the evidence and testimony provided to the State Board demonstrates unequivocally that improved freshwater flow conditions (increased volumes of freshwater flow during key periods that match the needs imposed by the life histories and ecology of key species) must be part of any real solution to the Bay-Delta's ecological collapse – flow improvements are essential, even if flows alone are insufficient to address all the Bay-Delta's environmental challenges.

[4] United States Department of Interior. July 29, 2010. Comments regarding the California State Water Resources Control Board Draft Report: Development of flow criteria for the Sacramento-San Joaquin Delta Ecosystem. Available at:

> *Native fish populations dependent on the Delta have declined across the board, with some species on the brink of extinction. Food web dynamics have undergone significant changes in both abundance and composition. While we do not discount the importance of other stressors on the Delta ecosystem, such as urban runoff, other pollutants, and invasive species, flow in the Delta is one of the primary determinants of habitat availability and one of the most important components of ecosystem function. Timing, magnitude and variability of flow are the primary drivers of physical habitat conditions including: turbidity, temperature, particle residence time, nutrient loading, etc. The Draft report's recommendations to mimic the natural hydrograph under different hydrological conditions (both Delta inflows and Delta outflow) is consistent with the information provided to the State Board by most of the scientific experts involved in this process.* [p. 1]

Subsequent scientific information discussed in our Workshop 1 submission and below reinforces these conclusions.

[California Department of Fish and Game. 2010. Quantifiable biological objectives and flow criteria for aquatic and terrestrial species of concern dependent on the Delta. Available at: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=25987]

DFG's final report on flow criteria for the Delta was released in December 2010. The Department concluded that,

> *Fish population declines coupled with these hydrologic and physical changes suggest that current Delta water flows for environmental resources are not adequate to maintain, recover, or restore the functions and processes that support native Delta fish.* [p. 1]

They also concluded that flow is the critical factor for native fisheries in the Delta:

> *Flow is the critical factor in maintaining suitable habitat conditions that support all or some of the life stages (spawning, rearing, and adult) of native fish species that depend on the Delta and its tributaries. Flow is the key factor in determining or maintaining water quality factors which determine the extent and suitability of habitat, temperature, turbidity, salinity, and dissolved oxygen.* [p. 96]

DFG summarized its findings as follows:

> *Water flow is a major determinant of species abundance and fish production. In general, the data and information available indicates:*
>
> 1. *Recent Delta flows are insufficient to support native Delta fishes in habitats that now exist in the Delta.*

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http://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/deltaflow/docs/closing_comments/doi_closing.pdf

2. *Water flow stabilization harms native species and encourages non-native species.*
3. *For many species, abundance is related to water flow timing and quantity …*
4. *For many species, more water flow translates into greater species production or abundance.*
5. *Species are adapted to use the water resources of the Delta during all seasons of the year, yet for many, important life history stages or processes consistently coincide with the winter-spring seasons and associated increased flows because this is the reproductive season for most native fishes and the timing of outmigration of most salmonid fishes. Examples:*
    a. *Propagation of splittail depends on the annual winter-spring flooding of the floodplains.*
    b. *Salmon life stages in the Sacramento River depend on certain base and pulse flows.*
    c. *Salmon life stages in the San Joaquin River need spring outflow to transport smolts through the Delta.*
    d. *Spring pulse flows in the Mokelumne River and other eastside streams are needed to support localized in-Delta water quality, salmon migration, and floodplain inundation.*
    e. *Winter Delta outflow has a positive effect on delta smelt.*
    f. *Fish species are dependent on adequate water temperature in spawning and rearing areas upstream of the Delta and sufficient dissolved oxygen for egg incubation, juvenile development, rearing, smolting, and migration.*
6. *The source, quantity, quality, and timing of Central Valley tributary outflow affects the same characteristics of mainstem river flow to the Delta and interior Delta water flows. Flows in all three of these areas influence production and survival of Chinook salmon in both the San Joaquin River and Sacramento River basins.*
7. *Some invasive species negatively influence native species abundance. The best evidence is the negative effects of overbite clam and several species of aquatic plants. Certain flows in and through the Delta may influence these undesirable species, both positively and negatively.*
8. *More research is needed on the effects of nutrients on the Delta ecosystem and its food web.…* [pp. 94-95]

The Department explicitly acknowledged the Delta ecosystem has been fundamentally altered, but concluded that implementing a combination of adequate flows and other measures can restore and maintain fisheries in good condition. [p. 96]

1. AQUATIC SPECIES POPULATIONS DISPLAY STRONG, PERSISTENT, HIGH ORDER CORRELATIONS BETWEEN RELEVANT INDICATORS OF FRESHWATER FLOW CONDITIONS

In our Workshop 1 submission, we reviewed data, scientific information and publications that have come to light since publication of the Delta Flow Report with respect to the effect of freshwater flow on the Low Salinity Zone and the species that reside or spawn in that environment, including Thomson et al 2010, Mac Nally et al 2010, Rosenfield 2010, FWS 2012, and NRC 2012. These new studies, life cycle models, and reviews all found strong relationships between outflow and longfin smelt abundance and viability, as well as persistent relationships between outflow and copepods that comprise the prey base for delta smelt and longfin smelt (TBI et al 2012: 7-16)

Pelagics – winter-spring outflow -- As we emphasized in our 2010 submission to the State Board (TBI et al 2010, Exhibits #1 and #2) and in our submission for Workshop 1 of the current proceeding, populations of numerous pelagic species (fish and invertebrates) have displayed statistically significant, high power (over orders of magnitude), correlations with Delta outflow over several decades of fish community sampling. Although "correlation is not causation", statistically significant correlations are rarely accidental (that is the entire meaning behind statistical significance) and the existence of such strong relationships across a wide diversity of species is incredibly powerful evidence that Delta freshwater flows drive (or interact strongly with the drivers of) population dynamics of aquatic species in the Delta. In fact, we know of no other single factor that better explains population dynamics of more Bay-Delta species over the past 5 decades (the temporal extent of data from many of our aquatic community sampling programs). Although the specific mechanism (or, more likely, *mechanisms*) behind these flow relationships remain somewhat uncertain, the State Board correctly declared in its 2010 Delta Flow Report:

> *There is sufficient scientific information to support the need for increased flows to protect public trust resources; while there is uncertainty regarding specific numeric criteria, scientific certainty is not the standard for agency decision making* [SWRCB 2010:4]

Mechanisms

Different flow-related mechanisms are believed to produce the similar responses to Delta outflow displayed by numerous species in the bay-Delta ecosystem (Kimmerer 2002 *and including species not explicitly studied by Kimmerer*). The four species whose population dynamics are depicted in Figure 1 represent three very different families of fishes and one invertebrate, and wide variety of life history patterns and ecological tolerances. Yet, these, species, and others not depicted here, have shown very similar relationships between abundance and winter-spring freshwater outflow for several decades (e.g., Stevens and Miller 1983, Jassby et al. 1995; Kimmerer 2002a; Sommer et al. 2007; Kimmerer et al. 2009; Mac Nally 2010).

It is almost certain that these species are responding to different flow-related mechanisms. For example, as described below, Sacramento splittail probably benefit from the effect of flow on

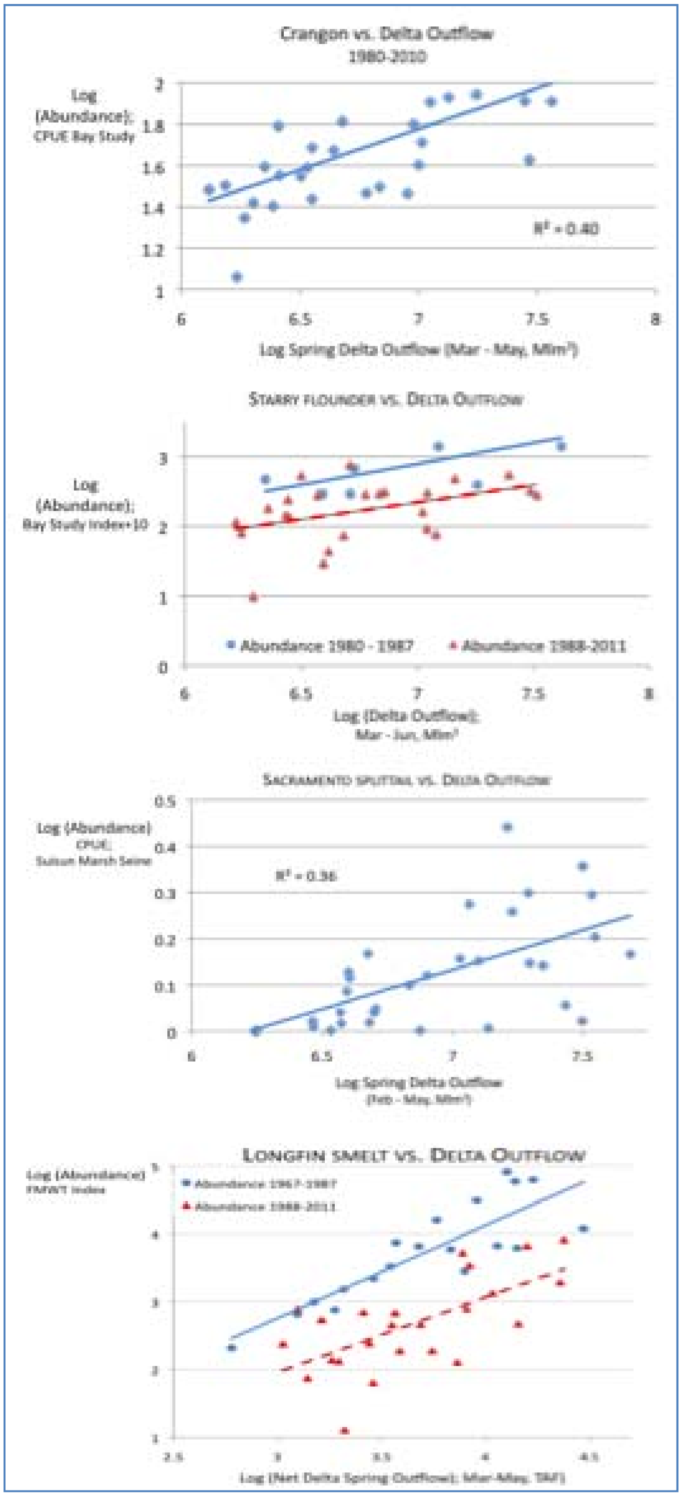

Figure 1: Long -term relationship of abundance indices with Delta freshwater outflow for four species of fishes native to the estuary. All relationships, except for the 1980-1987 starry flounder v. abundance relationship (p=0.075) are statistically significant.

creation and quality of spawning habitat as well as on transport to splittail rearing habitat in the Delta-proper and beyond; longfin smelt larvae and starry flounder juveniles rarely, if ever, occur on floodplains and are much more likely to benefit from kinetic energy mechanisms (low-salinity zone habitat area and position and retention from gravitational circulation in the estuary). The abundance of starry flounder and the bay shrimp, *Crangon franciscorum*, almost certainly respond to the strength of gravitational circulation (Kimmerer 2002a, b) and, probably also to the volume of available brackish habitat.

Just as the particular mechanisms driving the flow-abundance relationship for some species are unknown, those species/life stages for which a flow-related mechanism has been described may also be affected by additional, complimentary mechanisms that have not yet been studied. For example, the relationship between Sacramento splittail (a minnow species, found nowhere else in the world) and fresh water flow rates arises in part from this species' reliance on inundated floodplains for spawning and rearing (e.g. Sommer et al. 2001); clearly, floodplain inundation is very important to this species. Floodplain inundation is an interaction of floodplain elevation (or levee elevation) and the volume of freshwater flow. The relationship between floodplain inundation flows and splittail abundance is not binary (flood or no flood) – season, frequency, and duration of inundation are all extremely important (e.g., Moyle et al 2002, Sommer et al. 2001). Furthermore, even after a floodplain has been inundated, the magnitude of flow across the floodplain is an important indicator of the benefits it provides to native fishes (Figures 2 and 3).

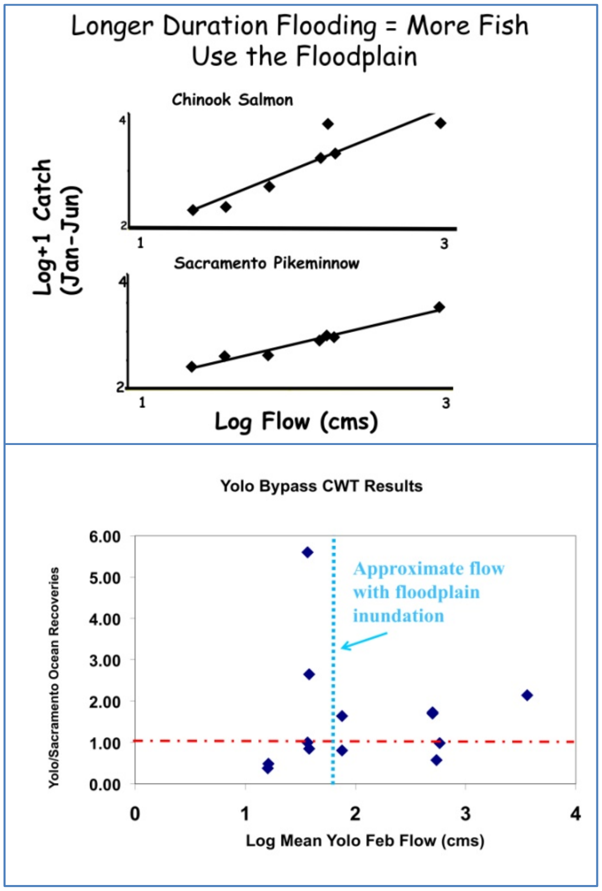

Figure 2: Chinook salmon survival (tag recoveries) as a function of flow rate on the Yolo Bypass. Figure from T. Sommer, CDWR, *personal communication*

The well-documented relationship between floodplain inundation and abundance of splittail (or other species) does not preclude or "disprove" additional mechanisms driving relationships between splittail abundance (or abundance of other fish) and flows elsewhere in their range, including Delta outflow. Given that juvenile and post-spawning splittail adults (and rearing Sacramento blackfish[5] and juvenile Chinook salmon that also use floodplains) move quickly from the floodplain habitats into the lower estuary, it is very likely that a mechanistic relationship between survival and Delta flow rates exists, although it is difficult to tease apart the effect of Delta inflow and Delta outflow in this case. Indeed, the Suisun Marsh Study (O'Rear and Moyle 2010) describes a likely mechanism by which Delta outflow affect Sacramento splittail (and other fish) populations in the Marsh:

> *… the timing, variability, and magnitude of Delta outflow continue to be important factors affecting the abundance of fishes recruiting into the marsh from upstream or downstream areas ... Additionally, Delta outflow, through its influence on marsh salinities, has also affected fishes produced in the marsh* [p 3].

For this reason, Figure 1 portrays the relationship between Sacramento splittail abundance in Suisun Marsh and Delta outflow; for simplicity's sake, we have not presented an analogous graph of Delta inflow and splittail abundance because we take that relationship as a given.

2. FLOW AND ANTECEDENT POPULATION (STOCK) EXPLAIN THE VAST MAJORITY OF VARIATION IN LONGFIN SMELT POPULATION SIZE AND REDUCED DELTA OUTFLOWS LIMIT LFS RESILIENCE AND PRODUCTIVITY

Longfin smelt and starry flounder both exhibit a "step decline" in the relationship between abundance and freshwater flow after 1987 that is commonly associated with the introduction and invasion of the Amur clam (*Corbula amurensis*; Figure 1). Much has been made of this significant change in the number of fish that correspond to any given flow for these two species, including assertions that this change indicated that flow was no longer a driving force for

[5] *Orthodon microlepidotus*, is a Central Valley native fish species. A cyprinid (minnow), it is the only member of its genus. This fish is caught and sold commercially, particularly in Asian markets.

abundance of these two species; such conclusions reflect a fundamental lack of statistical understanding. For both species, the statistically significant, high power, and persistent relationship between winter-spring Delta outflow and subsequent abundance remains; even the slope of the relationship has not changed (Kimmerer 2002; Rosenfield and Baxter 2007; Kimmerer et al. 2009; TBI et al. 2010, exhibit #2), meaning that for each incremental increase or decrease in annual flow, we see the same proportional increase in abundance today as we saw in the pre-clam period. This bears repeating: *for both longfin smelt and starry flounder, abundance has historically been and still is strongly and significantly correlated with winter-spring freshwater outflow from the Delta*. Additionally, the significant positive relationships between winter-spring Delta outflow (and its close correlate, X_2) and (a) bay shrimp abundance, (b) striped bass survival, (c) Sacramento splittail abundance, and (d) Pacific herring survival remained unchanged following the introduction of the amur clam and the abundance of American shad *increased* at any given flow following the introduction of the amur clam,[6] (Kimmerer 2002a).

In our 2010 testimony to the Board (TBI et al. 2010 Exhibit 2), we demonstrated that, *even following the introduction of the Amur clam*, inter-generation population growth was strongly and positively associated with winter-spring Delta outflows. This analysis demonstrated that the population size in any one year was related both to environmental conditions that prevailed during the winter-spring larval-juvenile rearing period and to the antecedent population size of the generation that produced the current stock of longfin smelt. By accounting explicitly for the size of the spawning stock, this analysis removed the effect of environmental variables that display a time-trend (e.g. ammonium concentration, phytoplankton concentration, etc.) -- impacts of these variables are already reflected by the stock variable. Only conditions that occur within the two-year generation length of longfin smelt can affect the *change* in abundance between sequential generations. This “stock-recruit” or (more accurately) “stock-stock” effect is well known in fisheries biology and, in particular, among the longfin smelt population in this estuary (Rosenfield and Baxter 2007; Mac Nally et al. 2010).

3. Ecological Implications of Reduced Delta Inflow

As described in our previous testimony (TBI et al. 2010, exhibits 1-4) and our Workshop 1 submission (TBI et al 2012), severe alteration of the historical Delta inflow hydrograph (including the magnitude, timing, frequency, and duration of flows) reduces the viability of numerous species that contribute to the Public Trust. We list a small sample of these effects below (and note that there are likely to be similarly significant effects for species/attributes of viability that have not been well-studied at this time):

- Reduced access of native fishes (including splittail, Chinook salmon, Sacramento blackfish, etc.) to inundated floodplains and side channel rearing areas during the appropriate season and for the necessary duration to facilitate their spawning, rearing, and migration (*impact*: reduced abundance and productivity)

[6] Little attention has been paid to populations of American shad, which displayed a step-increase in population for any given flow after the clam invasion (Kimmerer 2002); shad live mainly in the freshwater Delta; their abundance relationship with flow is contrary to what might be expected from suppression of the food web in the freshwater Delta.

- Inadequate transport flows from upstream spawning and rearing areas to and through the Delta (*impact*: reduced abundance and productivity, reduced nutrient and sediment transport affects ecosystem productivity in the Delta)
- Diminished and or undetectable migration cues for both downstream migrants (e.g. salmon smolts) and upstream migrants (e.g. spawning salmon) (*impact*: reduced abundance, productivity, spatial distribution, and life history diversity)
- Migration pathways that are blocked by physical barriers (e.g. weirs) or physio-chemical barriers (e.g. temperature and low dissolved oxygen) (*impact*: reduced spatial distribution and life history diversity)

4. Considerations for Implementing Flow Standards Based on a Percentage of Unimpaired Flow

As detailed in our Workshop 1 submission, the National Research Council has endorsed the Board developing flow objectives as a fixed percentage of unimpaired flows:

> *… it appears that if the goal is to sustain an ecosystem that resembles the one that appeared to be functional up to the 1986-93 drought, exports of all types will necessarily need to be limited in dry years, to some fraction of unimpaired flows that remains to be determined. Setting this level, as well as flow constraints for wetter years, is well beyond the charge of this committee and accordingly we suggest that this is best done by the SWRCB, which is charged with protecting both water rights holders and the public trust.* [NRC 2012: 105]

We strongly agree that the Board should develop new objectives for Sacramento River (and San Joaquin River) inflow and Delta outflow in the winter and spring months based on a percentage of unimpaired flows. Such standards (with a narrow time-period for averaging and measuring the percentage of unimpaired flows that is feasible, such as 14 days) should form the basis[7] of new flow standards in a revision to the WQCP.

Constructing flow recommendations as a percentage of unimpaired flows will also result in great improvements in the timing, duration, and frequency of actual flows into, through, and out of the Delta because the percentage of unimpaired flows approach results in flows that mimic the pattern of natural hydrological conditions (the conditions that native species evolved with) in the ecosystem. We note that, as the percentage of unimpaired flows increases, the timing, duration, and frequency of critical flows will more closely match unimpaired flows – thus, with a standard based on a percentage of unimpaired flow, the magnitude of flows that the Board allocates to protection of the Public Trust is directly connected to other beneficial attributes of flow, including timing, duration, and frequency of beneficial flows.

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[7] We recommend the use of the percentage of flow (POF) approach with respect to winter-spring inflows and outflows, while also recognizing that the Board may need to deviate from this basic template in specific cases, such as human health and safety benefits (e.g., flood control and human drinking water needs), as well as to provide flows in other seasons to provide other benefits (for instance, to mitigate impacts to salmon species that rely on upstream operations to provide habitats that were cut-off by construction of impassable dams).

The percentage of unimpaired flow approach is strongly supported in the literature, however, the Board's 75% criteria is actually low compared to other systems in which a "percentage of flow" (POF) approach has been implemented. The State Board's (2010) findings regarding the freshwater flow needs of this ecosystem represent a dramatic improvement over current flow conditions, and we firmly believe that such significant improvements are essential to restore the Bay-Delta's Public Trust resources (especially in the absence of credible plans to address other stressors in this ecosystem).

[Richter, B.D. M.M. Davis, C. Apse, and C. Konrad. 2011. A presumptive standard for environmental flow protection. River and Research Applications. River research and applications. DOI: 10.1002/rra.1511]

Richter et al. (2011) conducted a review of ecologically protective river flow standards developed by experts for other river systems to determine whether a presumptive standard could be developed for use when more exhaustive and detailed review and analysis of a particular system's needs had not or could not be performed. Although we believe that the State Board is appropriately engaged in a detailed analysis of Central Valley flow needs that supersedes application of a default, presumptive flow standard, Richter et al.'s findings are still informative as they set a context for protective standards in this system. Richter et al.'s review (and their significant professional expertise in the area of river hydrology and conservation) led them to conclude that:

> *"… a large body of scientific literature supports the 'natural flow paradigm' as an important ecological objective to guide river management (Richter et al., 1997; Poff et al., 1997; Bunn and Arthington, 2002; Postel and Richter, 2003; Arthington et al., 2006). Stated simply, the key premises of the natural flow paradigm are that maintaining some semblance of natural flow regimes is essential to sustaining the health of river ecosystems and that health is placed at increasing risk with increasing alteration of natural flows (Richter et al., 2003; Richter, 2009).*
>
> and
>
> *The POF* [percentage of natural flow] *approach has several strong advantages over other approaches. For instance, the POF approach is considerably more protective of flow variability than the minimum threshold standards. Minimum‐threshold‐based standards can allow flow variability to become 'flat‐lined' as water allocation pressure increases and reservoir operations are designed only to meet minimum release requirements. Statistically based standards, although usually more protective of flow regimes than minimum thresholds, can be confusing to non‐technical stakeholders, and complex statistical targets have proven difficult for water managers to implement (Richter, 2009). By comparison, POF approaches are conceptually simple, can provide a very high degree of protection for natural flow variability and can also be relatively simple to implement (i.e. a dam operator simply releases the prescribed*

percentage of inflow, or cumulative water withdrawals must not reduce flow by more than the prescribed percentage).

and

We found the recommendations for flow protection emerging from … expert groups to be quite consistent, typically resulting in a range of allowable cumulative depletion of 6% to 20% of normal to low flows, but with occasional allowance for greater depletion in seasons or flow levels during which aquatic species are thought to be less sensitive (Table II). These results suggest a consensus that modest alteration of water flows can be allowed with minimal to no harm to aquatic ecosystems and species.

Table 1: Summary table of environmental flow standards case studies. Copied from Richter et al (2011).

Table II. Summary of per cent-of-flow environmental flow standards from case studies

Location	Ecological goal	Cumulative allowable depletion	Considerations	Decision process
Florida (SWFWMD)	Avoid significant ecological harm (max. 15% habitat loss)	8–19% of daily flow	Seasonally variable extraction limit; 'hands-off' flow	Scientific peer review of site-specific studies
Michigan	Maintain baseline or existing condition	6–15% of August median flow	Single extraction limit for all flow levels	Stakeholders with scientific support
Maine	Protect class AA: 'outstanding natural resources'	10% of daily flow	Single extraction limit for all flow levels above a 'hands-off' flow level	Expert derived
European Union	Maintain good ecological condition	7.5–20% of daily flow	Lower flow; warmer months; 'hands-off' flow	Expert derived
		20–35% of daily flow	Higher flow; cooler months	

and

We suggest that a <u>high level of ecological protection will be provided when daily flow alterations are no greater than 10%</u>; a high level of protection means that the natural structure and function of the riverine ecosystem will be maintained with minimal changes. A <u>moderate level of protection is provided when flows are altered by 11–20%</u>; a moderate level of protection means that there may be measurable changes in structure and minimal changes in ecosystem functions. <u>Alterations greater than 20% will likely result in moderate to major changes in natural structure and ecosystem functions, with greater risk associated with greater levels of alteration in daily flows</u>. These thresholds are well supported by our case study review, as well as from our experiences in conducting environmental flow assessments for individual rivers (e.g. Richter et al., 2003, 2006; Esselman and Opperman, 2010). [Richter et al. 2011, emphasis added]

As the State Board prepares to implement flow standards needed to protect and restore the Bay-Delta's critically imperiled Public Trust resources, water managers will undoubtedly raise concerns that such standards cannot be implemented because of operational constraints or water supply implications. It is instructive that Richter and his colleagues have encountered some of these same concerns in other river systems, writing that:

> *In our experiences in working with water and dam managers, we have found that a remarkable degree of creativity and innovation emerges when engineers and planners are challenged to meet targeted or forecasted water demands with the least disruption to natural flow patterns. Solving the water equation will require new thinking about how and where to store water, conjunctive use of surface water and groundwater, sizing diversion structures or pumps to enable extraction of more water when more is available during high flows, sizing hydropower turbines such that maximum power can be generated across a fuller range of flows, and other innovations. When such creativity is applied as widespread common practice, human impacts on freshwater ecosystems will most certainly be reduced substantially.* [Richter et al. 2011]

Finally, we agree with Richter et al.'s (2011) recommendation about how to proceed *if* the State Board opts not to provide the level of flow protection that it has already determined will be necessary to protect fisheries resources and other aspects of the Bay-Delta's Public Trust values (SWRCB 2010):

> *Some water managers will feel excessively constrained by having to operate within the constraints of the presumptive sustainability boundaries suggested here. However, managing water sustainably necessarily implies living within limits (Richter et al., 2003; Postel and Richter, 2003; Richter, 2009). We suggest that a strong social imperative has emerged that calls for setting those limits at a level that avoids damaging natural systems and the benefits they provide, at least as a default presumption. Where other socio‐economic priorities suggest the need for relaxation of the presumptive sustainability boundaries we suggest here, we strongly encourage governments and local communities to invest in thorough assessments of flow–ecology relationships (Richter et al., 2006; Poff et al., 2010), so that decision making can be informed with scientific assessment of the ecological values that would likely be compromised when lesser degrees of flow protection are adopted.* [Richter et al. 2011]

B. REDUCED DELTA FRESHWATER INFLOWS AND INCREASING SOUTH DELTA WATER EXPORTS RESULT IN ENTRAINMENT MORTALITY AND GENERATE IN-DELTA FLOW PATTERNS (HYDRODYNAMICS) THAT INCREASE THE ECOLOGICAL FRAGMENTATION WITHIN THE DELTA AND BETWEEN THE LOWER BAYS AND RIVER CORRIDORS.

As increasing amounts of water are removed from the southern Delta by the State and Federal water Projects and Delta inflows decrease, flow patterns in Delta channels are increasingly disrupted. These disruptions lead to a variety of ecological effects, including increased retention time, net reverse flows, inaccurate migratory cues (e.g. physico-chemical gradients that fish use to cue their migration pathway and timing), export of nutrients and food items, and entrainment of fishes. The last of these effects receives the bulk of public attention, probably because the notion of millions of fish every year being drawn into the export facilities is so compelling and the harm this causes is readily understood.

1. Recent Studies and Life Cycle Models Demonstrate Substantial Adverse Effects of Altered Flows and Entrainment on Delta Smelt

[Kimmerer, W.J. 2011. Modeling Delta Smelt Losses at the South Delta Export Facilities. San Francisco Estuary and Watershed Science, 9(1). Available at: http://escholarship.org/uc/item/0rd2n5vb]

[Miller, W.J. 2011. Revisiting assumptions that underlie estimates of proportional entrainment of delta smelt by state and federal water diversions from the Sacramento-San Joaquin Delta. San Francisco Estuary and Watershed Science 9(1). Available at: http://escholarship.org/uc/item/5941x1h8.pdf]

In response to a critique of his earlier paper (Kimmerer 2008[8]) that attempted to estimate the population level impact of entrainment mortality on populations of salmon and Delta smelt, Kimmerer (2011) modified and expanded his earlier analysis. This re-analysis of entrainment-related impacts to Delta smelt concluded that:

> *Miller* [2011, to which Kimmerer 2011 responds] *raises some valuable points about the data and methods used in calculating proportional losses. He also introduces new developments in understanding (e.g., turbidity effects) and in the delta smelt population (e.g., spatial distribution) that occurred recently. I do not believe these points cast doubt on the overall conclusion of my paper, which is that export–related losses to the delta smelt population during some of the years analyzed were substantial.* [Kimmerer 2011:8, emphasis added].

Kimmerer further addresses Miller's (2011) chief complaint, which was that entrainment-related population impacts to Delta smelt are not detectable on a continuous basis throughout the Delta smelt population abundance index record. Kimmerer's analysis demonstrates that:

> *… the* [entrainment-related] *losses were not generally detectable in the regression until* P_{max} [the maximum decrement in the population by the end of the season attributable to export pumping] *reached about 60% to 80%. The levels of loss reported by Kimmerer (2008) were obscured by interannual variability in nearly all simulations, and maximum losses less than 20% were undetectable. Yet a* P_{max} *of 20% (mean annual loss of ~10%) results in a 10-fold reduction in population size by the end of the 26–year simulation (Figure 3). Repeating the above simulation 10,000 times with* P_{max} *= 20%, the upper 95% and 90% confidence limits of the regression slope excluded zero (i.e., was statistically detectable) in 5% and 9% of the cases, respectively. Thus, a loss to export pumping on the order reported by Kimmerer (2008) can be simultaneously nearly undetectable in regression analysis, and devastating to the population. This also illustrates how inappropriate statistical significance is in deciding whether an effect is*

[8] Kimmerer, W.J. 2008. Losses of Sacramento River Chinook salmon and delta smelt to entrainment in water diversions in the Sacramento-San Joaquin Delta. San Francisco Estuary Watershed Science 6(2). Available at: http://escholarship.org/uc/item/7v92h6fs

> <u>*biologically relevant*</u> *(Stephens and others 2007).* [Kimmerer 2011:7, emphasis added].

Kimmerer, who has previously published papers showing that entrainment did not appear to have population level effects on striped bass or mysids, acknowledged that *"my labors on export losses of delta smelt began with a strong skepticism about the importance of these losses, and ended with considerable surprise at their magnitude."* [Kimmerer 2011:8]

[Thomson, J.R., W.J. Kimmerer, L.R. Brown, K.B. Newman, R. Mac Nally, W.A. Bennett, F. Feyrer, and E. Fleishman. Bayesian change point analysis of abundance trends for pelagic fishes in the Upper San Francisco Estuary. Ecological Applications 20:1431-1448. Available at: http://online.sfsu.edu/~modelds/Files/References/ThomsonEtal2010EcoApps.pdf]

[Mac Nally, R., J.R. Thomson, W.J. Kimmerer, F. Feyrer, K.B. Newman, A. Sih, W.A. Bennett, L. Brown, E. Fleishman, S.D. Culberson, and G. Castillo. 2010. Analysis of pelagic species decline in the upper San Francisco Estuary using multivariate autoregressive modeling (MAR). Ecological Applications 20:1417-1430. Available at: http://online.sfsu.edu/~modelds/Files/References/MacNallyetal2010EcoApps.pdf]

These two intensive analyses of pelagic species population dynamics in the estuary (co-authored by many of the leading researchers in the Bay-Delta) found that entrainment/salvage appeared to have a population level impact on Delta smelt and other pelagic species.

> *Increases in water exports in both winter and spring were negatively associated with abundance of delta smelt and increases in spring exports with abundance of threadfin shad. Losses of delta smelt previously have been related to exports through entrainment and mortality at pumping facilities and may be important to population dynamics under some circumstances, particularly during dry years (Kimmerer 2008). Effects of spring exports on threadfin shad have not been measured but possibly are important given that this is the only species of the four to occupy freshwater throughout its life cycle and whose main distribution is near the export facilities (Feyrer et al. 2009).* [Thomson 2010:1426]

Mac Nally et al. (2010) found that high summer water temperatures, spring water exports, abundance of largemouth bass, abundance of summer calanoid copepods, and winter water exports were negatively associated with Delta smelt abundance to some degree. The modeled covariates explained 51% of the variability in abundance, and the authors concluded that water exports and X_2 are associated with the declines and can be managed.

[Maunder, M.N. and R.B. Deriso. 2011. A state–space multistage life cycle model to evaluate population impacts in the presence of density dependence: illustrated with application to delta smelt (*Hyposmesus transpacificus*). Can. J. Fish. Aquat. Sci. 68: 1285–1306. Available at: http://www.nrcresearchpress.com/doi/pdf/10.1139/f2011-071].

This paper described a life cycle modeling framework, which it illustrated with application to Delta smelt. Maunder and Deriso (20111) reached very different conclusions regarding the factors affecting Delta smelt than Mac Nally et al. (2010), Thomson et al. (2010), or Kimmerer (2011). The paper's principle finding is that parameters of, and variables identified as important by, its multi-stage population modeling framework were heavily influenced by a finding of density-dependent population dynamics among Delta smelt – a finding that the authors admit "*… was probably heavily influenced by three consecutive years of data*" from early in the data record (Maunder and Deriso 2012:1296). The authors concede that: "*At the recent levels of abundance, density dependence is probably not having a substantial impact on the population, and survival is impacted mainly by density-independent factors*" [Maunder and Deriso 2012:1303].

When populations experience density-dependent mortality, losses at a given stage may be somewhat mitigated by improved survival in later stages because the initial loss reduced impacts related to density (e.g. competition) in the later life stage. However, when population dynamics are density independent, losses at any given life stage are expected to translate proportionately to the final population size (they are not compensated for by increased survival later, because survival/mortality rates are not a function of density); for example, a loss of 10% of a populations eggs or larvae would be expected to result in a 10% decrement to the final adult population size. Thus, it is surprising that Maunder and Deriso (2012) conclude that entrainment of adult Delta smelt at the south Delta export facilities is probably unimportant to overall status of this species, despite the fact that: (a) Kimmerer (2009) concluded that Delta smelt salvage appeared to represent a substantial portion of the population periodically; (b) the authors acknowledge that Delta smelt survival is probably density-independent at current levels of abundance; and (c) the modeling framework they present <u>identified adult entrainment as a significant factor</u>. The authors wrote:

> *"The coefficients are similar magnitudes for most covariates except those for water clarity (Secchi) and, particularly, adult entrainment (Aent), which had much larger effects. These both occurred before the stock–recruitment relationship from adults to larvae, which had a very strong density dependence effect. Pred2 had a small effect. The confidence intervals on the coefficients support inclusion of the covariates in the lowest AICc* [=best] *models .... The effects for* [water clarity] *and* [adult Delta smelt entrainment] *appear to be unrealistically large, and their coefficients have a moderately high negative correlation. This appears to be a consequence of the unrealistically strong density dependence estimated in the stock–recruitment relationship from adults to larvae for those models …"* [Maunder and Deriso 2012: 1295].

The authors do not explain why they felt the effect of adult entrainment on population dynamics was too "large" to be retained in the model nor what it says about their modeling framework that they believed it mischaracterized the importance of two variables (Secchi depth and Adult Entrainment) and that its estimate of density dependence (the major finding of the manuscript) was "*unrealistically strong*." In summary, Maunder and Deriso's (2012) modeling framework found that entrainment of Delta smelt adults had a large effect on the population modeling, before the authors inexplicably removed that term from the model.

A. Scientific Critiques of Maunder and Deriso 2012

[BDCP "Red Flag" Documents [California Department of Fish and Game; US Fish and Wildlife Service; and National Marine Fisheries Service. April 2012 BDCP EA (Ch. 5) Staff "Red Flag" Review Comprehensive List. Available at: http://baydeltaconservationplan.com/Libraries/Dynamic_Document_Library/Effects_Analysis_-_Fish_Agency_Red_Flag_Comments_and_Responses_4-25-12.sflb.ashx]

[U.S. Fish and Wildlife Service 2012. First Draft 2011 Formal Endangered Species Act Consultation on the Proposed Coordinated Operations of the Central Valley Project and State Water Project. Available online at: http://www.usbr.gov/mp/BayDeltaOffice/docs/Signed_FINAL%202011-F-0043_%20SWP-CVP%20BO%20Dec%2014%20FIRST%20DRAFT.pdf]

[National Research Council. 2012. Sustainable water and environmental management in the California Bay-Delta. National Research Council. The National Academies Press, Washington, DC. Available at: https://download.nap.edu/catalog.php?record_id=13394]

As discussed below, the state and federal fishery agencies and the National Research Council have raised substantial criticisms regarding the accuracy of Maunder and Deriso (2012), including its conclusions regarding density dependence and effects of entrainment. For instance, in the Red Flag comments on BDCP, the Fish and Wildlife Service notes that:

> *… the Maunder-Deriso model is a new application that needs additional collaborative work before it reaches maturity. We are concerned that the present model may have identifiability problems, as we discussed in our technical comments last fall. Until that concern is resolved, we are unsure whether the parameter estimates developed in that model represent what they are described to represent.*
> ….
>
> *The model also assumes a specific form of density dependence between generations. We have questioned the appropriateness of this choice, because on very thin ground it limits the universe of plausible explanations for delta smelt reproductive success that can be derived from the model. The intent of this new model was to explain a specific historical dataset, and other than some broad assumptions it does not contain much of the mechanism presented in current delta smelt conceptual models (like DRERIP, or POD conceptual model, or the Fall Outflow Adaptive Management Plan conceptual model). The published version of the model used data through 2006. The model was updated for the Effects Analysis to include data through 2010. When this was done, the model fit deteriorated dramatically relative to what was reported in the paper.* [BDCP Red Flags 2012:18] (emphasis added)

Likewise, in its 2011 draft Delta smelt biological opinion, FWS raised similar questions about the Maunder and Deriso (2011) model, particularly its assumption of density dependent mortality. (FWS 2011) The Service explained that there is strong evidence of density dependence during the summer and fall months, but that since the early 1980s recruitment between generations has been density independent:[9]

> *Since the decline, recruitment has been positively and essentially linearly related to prior adult abundance, suggesting that reproduction has been basically density-independent for about the past 30 years. This means that since the early 1980s, more adults translates into more juveniles and fewer adults translates into fewer juveniles without being 'compensated for' by density- dependence.* [FWS 2011: 154; *see also* p. 193].

The Service reviewed the three life cycle models in the draft biological opinion and showed that they reached different conclusions regarding the role of winter and spring exports. (FWS 2011:206-213, 243-244) FWS concluded that adult entrainment can have significant effects on Delta smelt abundance because of the lack of compensatory density dependence and that the effects of entrainment would probably not be discernable using correlation statistics (citing Kimmerer 2011, *see above*). (FWS 2011) In the biological opinion, FWS reached similar conclusions with respect to juvenile entrainment, and recommended that proactive OMR restrictions in the spring are necessary. (FWS 2011:244-250)

The National Academy of Sciences also raised questions about the Maunder and Deriso (2011) model, stating that, *"Maunder and Deriso (2011) recently published a life cycle model of delta smelt. This model includes some assumptions that need further additional evaluation (e.g., role of density-dependent survival)."* (NAS 2012: 84)

Finally, it is important to note that, although Maunder and Deriso (2012) is presented, appropriately, as an illustration of a modeling framework, the outputs of that illustration are unreliable not only because of its assumption of density dependence, but also because of substantial concerns with the covariates used in the model. Many of these covariates underwent substantial mathematical manipulation that is not adequately explained, other covariates are not described with sufficient detail to be reproduced by other researchers, and many covariates appear irrelevant and/or not what their labels purport to be. As the authors acknowledge,

> *Several factors were chosen for inclusion in the model (Table 3). <u>These factors are used for illustrative purposes only, and they may differ in a more rigorous investigation of the factors influencing delta smelt</u>. The environmental factors are taken as those proposed by Manly (2010b).* [Maunder and Deriso 2012:1290] (emphasis added)

Thus, while the modeling *approach* developed by Maunder and Deriso (2012) may become useful in the future, it is unlikely to produce a valid *model* of Delta smelt population dynamics until the inputs to that framework include all of the variables that ecologists believe may be relevant to the Delta smelt population.

[9] Maunder and Deriso themselves acknowledged that the density-dependent term in their population model was related to three data points from the early 1980's and that at current abundances, survival was likely density-independent.

B. Estimates of Salvage Dramatically Underestimate Delta Smelt Mortality

[Castillo, G. J. Morinaka, J. Lindberg, Robert Fujimura, B. Baskerville-Bridges, J. Hobbs, G. Tigan, L. Ellison. (*in review*). Pre-Screen Loss and Fish Facility Efficiency for Delta Smelt at the South Delta's State Water Project, California. Submitted to San Francisco Estuary and Watershed Science. Available at: http://www.fws.gov/stockton/jfmp/docs/DRAFT-Delta-Smelt-Pre-Screen-Losses-SWP.pdf]

One of the major problems with estimating the overall effect of entrainment on any particular fish species is that we are only able to directly measure "salvage", which is related to the number of fish species enumerated at the fish screening facilities of the State and Federal Water Projects. These facilities do not enumerate losses of fish eggs or larvae that are too small to respond to the behavioral screening system. In addition, predation just outside the fish screens is known to be extraordinarily high because predators aggregate in this area and have been trained to respond to the daily operations of the export facility (e.g. opening of intake gates). Historically, these pre-screen (but, post-entrainment into the diversion canals) losses have been estimated by multiplying salvage by a factor <10. Castillo et al (*in review*) reports on experimental releases of fish into Clifton Court Forebay. The study investigates "*two key sources of entrainment losses of delta smelt at the SWP: fish facility losses (i.e. fish lost within the fish facility due to partial louver efficiency and predation) and pre-screen losses in [Clifton Court Forebay]*. Their findings include:

> *Mean pre-screen losses increased over time: February (94.3%); March (99.1%) and June (99.9%). We concluded that: 1) entrainment losses of delta smelt could be higher at times compared to other species previously studied at the SWP; 2) pre-screen loss was the largest source of mortality for delta smelt; 3) increased distance from the SFF* [Skinner Fish Facility] *and residence time in CCF* [Clifton Court Forebay]*, and decreased exports, resulted in lower percent of recovered fish at the SFF.* [Castillo et al. *in review*]

In other words, the number of Delta smelt entrained into waterways directly adjacent to the State Water Project may be ~16 to 1000 times greater than that enumerated during salvage. More work is needed to understand the relationship between pre-screen mortality for Delta smelt and other fishes (to say nothing of the larger impact to fishes before they are drawn into the water bodies directly adjacent to the fish salvage facilities), but it is critical that the Board recognize that salvage estimates are an extremely small fraction of the actual (but unestimated) mortality that is directly attributable to South Delta exports.

C. Forthcoming Scientific Studies and Life Cycle Models Also Conclude that Entrainment Has Population Level Effects on Delta Smelt

[Rose, K.A., W. J. Kimmerer, K.P. Edwards, and W.A. Bennett. *in prep.*, Individual-based population dynamics model of delta smelt: comparing the effects of food versus entrainment. Abstract Available at: http://www.water.ca.gov/iep/docs/041812agenda_abstracts.pdf]

Rose et al are developing an individual-based population dynamics model that they intend to use to assess potential causes of the Delta smelt population decline. While this work is ongoing, Dr. Rose presented the results to-date at the 2012 Interagency Ecological Program conference and reported that:

> *We simulated the population decline using 1995 to 2005 conditions, and explored the relative influence of historical changes in food and entrainment on delta smelt population dynamics. … Simulations indicated that the effect of entrainment on simulated delta smelt population growth rate was between 50% and equal to the effects of food; thus, both were important to the population decline. Increased understanding of how changes in food and entrainment affect delta smelt population dynamics will inform the protection and restoration of delta smelt.*

Several papers are being prepared for publication from this study, which should be available during this State Board proceeding.

[Bennett, W.J. 2012. Statistical Modeling of Unnatural Selection, and the Dialectics of Causation in the Decline of Delta Smelt. Presentation to the 2012 Interagency Ecological Program Conference]

In this presentation, one of the world's leading experts in Delta smelt ecology and population biology, Dr. Bill Bennett asks, "*Did water exports "Cause" the decline of delta smelt?*" and answers with an emphatic "*Yes*" [Slide 2]. The presentation identifies that detrimental entrainment-related impacts to Delta smelt include negative impacts to population abundance, productivity, spatial distribution, and life history. Thus, in addition to simple (though episodic) population-level impacts to Delta smelt, ongoing entrainment impacts have destroyed Delta smelt habitat and eroded the population's natural ability to recover and avoid temporally or geographically-restricted, catastrophic impacts. The author is preparing one or more publications based on the materials summarized in this presentation, which we hope will be published during this proceeding.

2. Entrainment of Longfin Smelt May Have Significant Population Level Effects in Some Years

[Rosenfield, J.A. 2010. Conceptual life-history model for longfin smelt (*Spirinchus thaleichthys*) in the San Francisco Estuary. California Department of Fish and Game, Sacramento, CA. http://www.dfg.ca.gov/ERP/conceptual_models.asp]

The California Department of Fish and Game's Ecosystem Restoration Program (formerly the CALFED ERP) has produced life history conceptual models for key native species. These models describe the magnitude and likelihood of impact of various stressors to particular life history stages of organisms that may contribute to the Public Trust. Regarding the impact of diversions on longfin smelt in this estuary, the CDFG life history conceptual model for longfin smelt (Rosenfield 2010) states that:

> *Mortality of sexually mature adult LFS at water diversions may represent a significant impact on the LFS population in some years (Tables 2, 3). .... Although overall entrainment (which largely reflects entrainment of Age 0+ fish) is significantly and negatively correlated with outflow …, entrainment of sexually mature Age 1+ LFS is significantly and positively correlated with fresh water export rates at the south Delta pumping facilities (ln(SWP+CVP exports):ln(age 1+ salvage)): $R^2 = 0.418$; $p < 0.01$; Fig 11). This result is consistent with that of Grimaldo et al. (2009) who studied the relationship between Old and Middle River flows (that are heavily impacted by export rates) and longfin smelt entrainment. This relationship is not an artifact of a correlation between entrainment and Age 1+ population size (Sommer et al. 2007). Age 1+ LFS entrainment is significantly negatively correlated with the Age 1+ LFS population size as measured by the FMWT index (Fig. 12). Entrainment has increased in recent years as the population declined.*
>
> *Spawning (Age 1+) LFS migrate eastwards, towards the Delta (Fig. 7). Their migration patterns expose these spawning fish (and their subsequent offspring) to entrainment at the CVP/SWP pumps. Significant Age 1+ LFS entrainment at CVP/SWP facilities has occurred in months between December and June. Between 1993 and 2007, longfin smelt entrainment was recorded in 12 years; in 7 of those years, the annual maximum entrainment occurred in January whereas December produced the maximum entrainment in three years.* [p. 21].

In addition, the conceptual model notes that entrainment/salvage mortality likely affects the spatial distribution of longfin smelt in addition to the negative impact to viability caused by negative effects of mortality on abundance:

> *Water export operations in the southern Delta may be responsible for the near-absence of spawning LFS in the lower San Joaquin River. The CVP/SWP pumps are located near where one would expect LFS to spawn in the lower San Joaquin River. If LFS spawned historically in areas of the San Joaquin River that were similar to those currently used in the lower Sacramento River, it is likely that CVP/SWP export operations entrained large numbers of spawning adults and recently- hatched larvae in this area. Deterioration of water quality in the lower San Joaquin River (a product of water exports and agricultural operations supported by those exports) could also be responsible for the absence of LFS spawning in this area if San Joaquin flows were toxic to developing eggs or prohibit spawning in this area. Furthermore, the low freshwater outflow rates from the San Joaquin River that result from operation of the larger hydrosystem may make this area unsuitable for spawning and/or incubation.*

[U.S. Fish and Wildlife Service. 2012. Endangered and Threatened Wildlife and Plants; 12-month Finding on a Petition to List the San Francisco Bay-Delta Population of the Longfin Smelt as Endangered or Threatened. 50 CFR Part 17. [Docket No. FWS-R8-ES-2008-0045]. Available at:

http://www.fws.gov/cno/es/speciesinformation/Longfin%20Smelt%2012%20month%20finding.pdf]

In its notice announcing that longfin smelt warranted protection under the Endangered Species Act, FWS acknowledged that entrainment can have significant effects:

> *Conversely, during low outflow periods, negative effects of reduced transport and dispersal, reduced turbidity, and potentially increased loss of larvae to predation and increased loss at the export facilities result in lower young-of-the-year recruitment.* [p. 38].

FWS analyzed the potential for significant entrainment effects, and found that entrainment levels in 2002 threatened the population.

[Salvage Data for Longfin smelt, 2012. Data available for download at: http://www.dfg.ca.gov/delta/apps/salvage/SalvageExportCalendar.aspx]

Salvage of longfin smelt during 2012 was among the highest recorded since 1993; through April, the number of Age 0 longfin enumerated at the salvage facility was second only to entrainment in 2002 (the year in which FWS suggested entrainment threatened the population). This occurred despite provisions in DFG's Incidental Take Permit (ITP) for the SWP. The ITP sets OMR flow targets based on detection of longfin smelt at a variety of sampling stations -- each of these OMR targets represents a net average negative ("reverse") flow. The ITP has no provision to increase Delta outflow, despite the wealth of documentation (e.g. Dege and Brown 2004; Grimaldo et al. 2009; Rosenfield 2010) that longfin smelt become susceptible to entrainment by the South Delta pumps only when X_2 is located relatively far to the east (i.e. during below normal and drier winter-springs). Nor does the ITP impose limits on how many longfin smelt may be entrained.

Based on the very high entrainment of longfin smelt in 2012, the low longfin smelt population currently, and the results of previous studies on entrainment of longfin smelt and other species (e.g. Grimaldo et al. 2009), I conclude that there is no scientific justification that would permit net negative OMR flows during larval and early juvenile period (April-May) of longfin smelt during years with hydrology that is classified as Critically Dry or Dry. Net negative flows represent a significant threat to several pelagic species under such conditions.[10]

3. ENTRAINMENT OF OTHER PELAGIC SPECIES

[Cloern J.E. and A.D. Jassby *in press.* Drivers of Change in Estuarine-Coastal Ecosystems: Discoveries from Four Decades of Study in San Francisco Bay. Submitted to the SWRCB in Workshop 1]

[10] In preparing this testimony, I reviewed TBI's previous submission to the Board on in-Delta hydrodynamics (TBI et al. 2010, exhibit #4). In so doing, I became aware that a recommendation we made regarding protective OMR flows for longfin smelt (which I helped to develop) was misreported as a result of a typographical error. The recommendation reported in TBI et al. (2010, exhibit #4) on p. 8 and also Table 1, p. 30 should have read that net OMR flows be positive (>0 cfs) during April and May during Critically Dry years, Dry years ***or*** whenever the preceding longfin smelt FMWT index is below 500. That was and remains my recommendation.

Although most attention is focused on entrainment of commercially valuable and/or listed species, CVP and SWP operations in the Delta also export a significant proportion of phytoplankton from the system. Jassby and Cloern conclude that:

> *Water export from the Sacramento-San Joaquin Delta is a direct source of mortality to fish, including imperiled species such as delta smelt and longfin smelt (Grimaldo et al., 2009; NRC, 2010), and export plus within-Delta depletion alters system energetics of an already low-productivity ecosystem by removing phytoplankton biomass equivalent to 30% of Delta primary production (Jassby et al., 2002).*

In addition to removal from the system, barriers, exports, flows and other operations affect residence time in the estuary, which affects the production and geographic distribution of phytoplankton biomass. For a system in which, many researchers believe, fish productivity is food limited, export and removal of Delta primary production (not to mention tens to hundreds of millions of fish, fish larvae, and fish eggs – which are all food for other fish and avian predators) represents a major impact.

[The Bay Institute. 2012. Collateral Damage: A citizen's guide to fish kills and habitat degradation at the state and federal water project pumps in the Delta. Novato, CA. Available at: http://www.bay.org/publications/collateral-damage]

Earlier this year, The Bay Institute produced a white paper describing a range of impacts caused by excessive south Delta exports, including specifically entrainment/salvage of huge numbers of a wide variety of species at the SWP and CVP export facilities. The report describes that:

> *•Every day, between 870 and 61,000 fish – including from 200 to 42,000 native and endangered fishes – are "salvaged" at the pumps. Most die in the process.*
>
> *•On average, over 9 million fish – representing the twenty fish species considered in this report – are "salvaged" each year at the pumps. As many as 15 million fish of all species encountered are "salvaged" each year.*
>
> *•Up to 40% of the total population of the endangered delta smelt and 15% of the endangered winter-run population of Chinook salmon are killed at the pumps in some years. In the first half of 2011, over 8.6 million splittail were salvaged.*
>
> *•Salvage estimates drastically underestimate the problem. The numbers do not factor in the results of "indirect" mortality, as high levels of export pumping disrupt fish migration, shrink the amount of non- lethal habitat available to fish species, and remove vast amounts of biomass, including fish eggs and larvae too small to be screened at the pumps.*
>
> *•Export pumping causes the lower San Joaquin River to flow backwards most of the year and removes the equivalent of 170 railroad boxcars of water – and the*

> *accompanying fish, other organisms, and nutrients – from the Delta ecosystem every minute*.
>
> •*Large numbers of fish being entrained is a problem even for species that are not currently listed as "endangered." Killing large numbers of fish year after year cuts off population growth in response to favorable conditions and can start the species on a downward path to extinction. As the species declines, the population impacts of entrainment become proportionately larger*.
>
> •*Entrainment is a real problem. But the same interests in the Delta export community who claim that it isn't also back constructing expensive new conveyance facilities such as a peripheral canal or tunnel to solve the problem that they say doesn't exist.* [TBI 2012:4]

Collateral Damage also documented a record salvage[11] of almost 9 million Sacramento splittail in 2011 (Table 2); as the report describes, the salvage total almost certainly vastly underestimates (by perhaps two orders of magnitude) the total mortality to this and every other fish species captured in the export facilities' salvage mechanism. Salvage of Sacramento sucker in 2011 (27,362 fish) was also a record for this species and the 203 white sturgeon juveniles captured at the south Delta export facilities represented the highest salvage total for that species since 1998.

Although it is true that abundances of many fish species increased in 2011 (which may account in part for increased salvage of splittail), it is extremely unlikely that 2011 (following on years of record or near-record low populations) was a year of record high abundance for native fishes (although it did produce the highest level of water export from the south Delta ever recorded). Also, the loss of tens to hundreds of millions of fish, fish larvae, and fish eggs represents a severe impact to the food web of an ecosystem whose productivity is said to be declining. This type of impact demonstrates how Bay-Delta water management reduces species' productivity – even when conditions become suitable for population growth, native fish populations are held down artificially by high direct and indirect mortality at the south Delta export facilities; thus, these populations cannot capitalize on good years to recover from years of artificially prolonged and severe drought.

[11] Most salvaged fish are believed to die either from handling, transport stress, or predation at release sites.

Table 2: Summary of salvage of selected species through time at the South Delta export facilities. Numbers do not reflect pre-screening mortality (believed to be up to 100 times greater than actual salvage), larval fish or eggs, or other negative impacts. Table copied from *Collateral Damage* (TBI 2012).

STATUS KEY:

- Endangered - Federal
- Endangered - California
- Threatened - Federal
- Threatened - California

LEGEND:

- Native to CA
- Recent decline
- Important Fishery
- Commercial/Sport Fisheries Destroyed
- Protection Removed (for political reasons; species has not recovered)

Selected Fish Species	1993-2011 Annual Salvage Average	Maximum	Status
American shad	1,022,700	2,510,184	Important Fishery; Recent decline
Bluegill	127,133	394,952	
Channel catfish	45,799	131,484	
Chinook salmon (winter run)	51,955	183,890	Endangered - Federal; Endangered - California; Native to CA; Commercial/Sport Fisheries Destroyed; Recent decline
Chinook salmon (spring run)			Threatened - Federal; Threatened - California; Native to CA; Commercial/Sport Fisheries Destroyed; Recent decline
Chinook salmon (fall run)			Native to CA; Important Fishery; Recent decline
Chinook salmon (late-fall run)			Native to CA; Important Fishery; Recent decline
Delta smelt	29,918	154,820	Threatened - Federal; Endangered - California; Native to CA; Recent decline
Green sturgeon	58	363	Threatened - Federal; Native to CA; Recent decline
Inland silverside	62,838	142,652	
Largemouth bass	54,180	234,198	Important Fishery
Longfin	6,228	97,686	Threatened - California; Native to CA; Recent decline
Prickly sculpin	76,403	274,691	Native to CA
Steelhead (Rainbow trout)	5,278	18,580	Threatened - Federal; Native to CA; Commercial/Sport Fisheries Destroyed; Recent decline
Redear sunfish	1,609	5,611	
Riffle sculpin	155	798	Native to CA
Sacramento sucker	3,443	27,362	Native to CA
Sacramento splittail	1,201,585	8,989,639	Protection Removed; Native to CA; Important Fishery; Recent decline
Striped bass	1,773,079	13,451,203	Important Fishery; Recent decline
Threadfin shad	3,823,099	9,046,050	Recent decline
White catfish	296,543	941,972	
White sturgeon	151	873	Native to CA; Important Fishery; Recent decline
Yellowfin goby	193,399	1,189,962	

Average yearly salvage total: 9,237,444

[1] Fish were selected to encompass the wide range of species and life history types that are affected by water pumps.

[2] "Average annual salvage" is mean yearly salvage from 1/1993 through 12/2011; "Maximum salvage" is the value for the calendar year with the highest salvage numbers (years differ among species).

These numbers underestimate the actual fish kills by not counting the fish that slipped through the bypass system and were killed by the pumps, and by not including indirect mortality. "Yearly Total" refers only to the 20 species listed.

RECOMMENDATIONS

With respect to pelagic species, we recommend that the Board consider the following measures in its update of the water quality control plan, consistent with the potential objectives identified in the 2009 staff report:

1. Delta Outflow Objectives: Increase winter/spring Delta outflow objectives, using a percentage of unimpaired flows approach, to achieve quantifiable targets for increased abundance of longfin smelt and zooplankton species (see our Workshop 1 submission for guidance on setting targets to define desired outcomes). Increase fall (and possibly summer) outflow objectives to achieve quantifiable targets for increased abundance of delta smelt.

2. Floodplain Habitat Flow Objectives: Establish Sacramento River inflow (and possibly structural modifications objectives) such that flows from the Sacramento River inundate floodplains for 15-120 days between December and May every year or twice in every three years.

3. Reverse Flow Objectives / Export: Inflow Objectives: Establish objectives limiting reverse flows in Old and Middle River (OMR) and/or other restrictions on hydrodynamics and exports (e.g., I:E ratios) that reduce entrainment and improve survival of pelagic species in the winter and spring months, including net positive OMR flows during Dry and Critically Dry year-types to help transport pelagic fishes away from the south Delta export facilities.

In our Workshop 1 submission (TBI et al 2012) we provided detailed recommendations regarding the use of adaptive management; we briefly expand on those recommendations here. In an Appendix to our Workshop 1 submission, we described the construction and application of a planning architecture we call "the Logic Chain." The Logic Chain sets conservation actions (such as those contained in the Water Quality Control Plan) in the context of overall and regionally specific goals (desired outcomes) and S.M.A.R.T. targets that articulate the goals (i.e. define what success looks like). Description of stressors that are believed to prevent attainment of the goal, stressor reduction targets (which are also S.M.A.R.T.) and the expected outcomes (positive and potential negative) of conservation actions force planners to identify the level of certainty and key assumptions behind different courses of action.

These assumptions and declarations regarding relative certainty of the response to specified actions become the fuel for an adaptive management implementation strategy. To the extent possible, adaptive management should actively seek to increase certainty and test assumptions that underlie the actions that are implemented. In theory, as different assumptions are tested and progress (or lack thereof) becomes clearer, the most effective and efficient pathways to the desired outcomes will come into focus.

However, this vision of adaptive management can only become reality if the implementation plan identifies specific outcomes/targets and specific and robust decision pathways that make clear how and under what circumstances management will "adapt" to new information and/or changing circumstances. Also, the decision pathways must identify what entities will make the decision to adapt, who has the final authority to make the decision to alter course, when (what time frame and under what circumstances) will those decisions be made, and what are the likely alternative actions. Decision pathways will thus identify adaptive management ranges, within which key variables will be managed to determine their effect, and adaptive management triggers, thresholds that when crossed lead to definitive adjustments in the implementation strategy.

The exact nature and structure of and adaptive management decision pathway depends in large part on information gleaned from the Logic Chain architecture (for example, what is the time bound (the "t" in SMART) for attainment of a particular conservation target?). Thus, we cannot develop a specific example of a decision pathway here. However, we strongly believe that, wherever an action plan will rely on adaptive management going forward, a clear and specific decision pathway should be defined in advance of implementing the relevant action. Developing the decision pathway "as we go along" is reactive management occurring under the guise of adaptive management. We stand ready to provide advice and expertise to the Board and Board staff on the development of these essential adaptive management decision-pathways as you move towards specific revisions of the Bay-Delta Water Quality Control Plan.

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CLOSING COMMENTS RELATING TO THE 2012 WORKSHOPS ON THE COMPREHENSIVE (PHASE 2) REVIEW AND UPDATE TO THE BAY-DELTA PLAN

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AND

RECOMMENDATIONS RELATING TO WORKSHOP 3 (ANALYTICAL TOOLS FOR EVALUATING WATER SUPPLY, HYDRODYNAMIC AND HYDROPOWER EFFECTS)

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STATE WATER RESOURCES CONTROL BOARD

On behalf of:

NATURAL RESOURCES DEFENSE COUNCIL
THE BAY INSTITUTE

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I. Closing Comments, Part One: Public Trust, Balancing, and Program of Implementation Issues That Must Be Addressed in Amending the Bay-Delta Plan

During the current review by the State Water Resources Control Board (Board) of the Bay-Delta Water Quality Control Plan ("Plan" or "Bay-Delta Plan"), questions have been raised regarding the Board's obligations under the public trust doctrine and other statutory requirements. In the first section of these closing comments for the 2012 Phase 2 workshops, we attempt to address these questions. In summary, the Board must ensure that the Bay-Delta Plan:

- Protects public trust resources to the extent feasible.
- Complies with the Board's obligation to conserve listed fisheries under the California Endangered Species Act.
- Discharges the Board's obligation to achieve the salmon doubling narrative objective.
- Considers alternative water supplies and the economic benefits of fishery protection in determining how to balance between competing beneficial uses and what water quality objectives are feasible and reasonable.

1. <u>The State Water Resources Control Board Must Ensure that the Bay-Delta Plan Protects Public Trust Resources to the Extent Feasible</u>

The promulgation of water quality standards for the Bay-Delta requires the Board to "establish such water quality objectives in water quality control plans as in its judgment will ensure the reasonable protection of beneficial uses and the prevention of nuisance." Cal. Water Code § 13241. In addition, in establishing water quality standards for the Bay-Delta the Board must also protect public trust resources "whenever feasible." *See National Audubon Society v. Superior Court*, 33 Cal.3d 419, 446 (1983); *State Water Resources Control Board Cases*, 136 Cal.App.4th 674, 777-78 (2006). As the Board has recognized in prior decisions,

> The State Water Resources Control Board has broad authority to establish minimum flows and take other measures needed for protection of fisheries and other public trust resources. That authority is provided by article X, section 2 of the California Constitution, Water Code sections 100 and 275, the public trust doctrine as articulated by the California Supreme Court in *National Audubon Society v. Superior Court* (1983) 33 Cal.3d 419 [189 Cal. Rptr. 346], and Water Code sections 1243 and 1253**.**

SWRCB Decision 1644 at p. 29. As the Board further recognized in that decision,

> The purpose of the public trust is to protect navigation, fishing, recreation, fish and wildlife habitat, and aesthetics. (*National Audubon Society v. State Water Resources Control Board, supra,* 33 Cal.3d at 434-435, 437 [189 Cal. Rptr. at 356, 358]; cert. denied, 464 U.S. 977.) Fish and Game Code section 5937 is a legislative expression concerning the public trust doctrine that should be taken into account when the SWRCB acts under its public trust authority. (See

> *California Trout, Inc. v. State Water Resources Control Board* (1989) 207 Cal.App.3d 585, 626, 631 [255 Cal. Rptr. 209, 212].)
>
> In applying the public trust doctrine, the State has the power to reconsider past water allocations even if the State considered public trust impacts in its original water allocation decision… **The State has the duty of continuing supervision over the taking and use of appropriated water and an affirmative duty to protect public trust uses whenever feasible**. (*National Audubon Society v. Superior Court*, *supra,* 33 Cal.3d at 445-448).

Id. at 30-31, emphasis added; *see* SWRCB, Decision1631, at 11 ("The *Audubon* decision establishes that the SWRCB has the additional responsibility to consider the effect of water diversions upon interests protected by the public trust and to avoid or minimize harm to public trust uses to the extent feasible.").

In exercising its duties, the Board must respect the rule of priority and other statutory protections for water rights, but even those rules must yield if they conflict with the public trust or reasonable use doctrines. *El Dorado Irr. Dist. v. State Water Res. Control Bd*., 142 Cal.App.4th 937, 944 (2006) ("Although the rule of priority is not absolute, the Board is obligated to protect water right priorities unless doing so will result in the unreasonable use of water, harm to values protected by the public trust doctrine, or the violation of some other equally important principle or interest."); *see id*. at 966 ("Thus, like the rule against unreasonable use, when the public trust doctrine clashes with the rule of priority, the rule of priority must yield. Again, however, every effort must be made to preserve water right priorities to the extent those priorities do not lead to violation of the public trust doctrine.").

2. <u>The Board Must Consider Water Conservation, Water Recycling, and Other Alternative Water Supplies Which are Available to Municipal, Industrial, and Agricultural Water Users in Determining the Feasibility of Protecting Public Trust Resources and the Reasonability of Water Quality Objectives that Protect Instream Beneficial Uses</u>

As the Board considers economic factors and competing beneficial uses of water in determining the reasonable protection of beneficial uses and the extent to which protection of public trust resources is feasible, the Board must also consider the ability and need to develop alternative water supplies, including recycled water[1], to meet other beneficial uses, such as municipal and agricultural uses. *See* Cal. Water Code § 13241(f).

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[1] *See, e.g.,* Water Code § 13511 ("The Legislature finds and declares that a substantial portion of the future water requirements of this state may be economically met by beneficial use of recycled water."); Water Code §§ 13510-13512, 13550 *et seq*. (legislative policy encouraging water recycling, directing the state to take "all possible steps" to encourage development of water recycling facilities, and finding certain uses of potable water unreasonable if recycled water is available that meets certain criteria).

Aquatic life is the least flexible use of the Bay-Delta's waters. The establishment and maintenance of sustainable fish and wildlife populations, habitats and ecological processes is highly dependent on maintaining adequate flow, temperature, and water quality conditions in the estuary. The populations and ecosystems of the Bay-Delta are naturally resilient, of course. The formal listing of numerous fish species as endangered, the unprecedented closure of the commercial salmon fishery, and the systemic decline in both ecosystem values and public recreational uses of the Bay-Delta's waters demonstrate, however, that this natural resilience has been exceeded as a result of large-scale hydrologic alteration in recent decades. Fish and wildlife beneficial uses entrusted to the Board's care are in danger of disappearing forever.

Native fisheries and other public trust resources in the Bay-Delta must rely exclusively on the waters of the estuary for their existence. In contrast, there are cost-effective, environmentally superior alternative water supplies available for municipal, industrial, and agricultural beneficial users of water from the Delta (as discussed in detail in the recommendations relating to Workshop 3 contained in Section II.1 below). These important beneficial uses of water have greater flexibility as a result of water users, water managers, and regulatory agencies such as the Board being able to implement a broad suite of management actions to more efficiently divert, store, and apply water supplies; secure water supplies from alternative sources; and/or switch to different activities to maintain economic viability. The Board must take these potential alternative water supplies into account when balancing competing beneficial uses and determining what level of public trust protection is feasible.

The Board has considered the availability of alternative water supplies in past Bay-Delta plans and in other proceedings. In 1978, the Board waived salinity protections in Antioch based on a determination that adequate substitute water supplies were available for municipal and industrial customers. SWRCB Decision 1485 at pp. 16-17.[2] In addition, in D-1485 the Board cautioned that future requests by the SWP and CVP to increase diversions or transfer water would be subject to careful scrutiny of the conservation and wastewater recycling programs in the service areas:

> "However, in its review of applications for additional appropriations by the CVP and SWP or of proposed transfer of water utilizing CVP and SW facilities, the Board will review conservation and wastewater reclamation programs in the proposed service areas to ensure that these additional water resources will be used in the most efficient manner possible consistent with the general public interest. Unappropriated water in California is an increasingly short, precious resource. As greater demands are made on a more limited unclaimed supply, the Board must scrutinize proposed uses more intensely than ever before to ensure that vested water rights and the public interest are protected."

[2] Because Antioch's water rights were protected under the Delta Protection Act (Water Code section 12202), the Department of Water Resources was obligated to pay for these substitute rights and ensure that they were of like quality and quantity. *Id*.

SWRCB Decision1485 at pp. 18-19. Similarly, in Decision 1631, in considering the impacts of reduced water supply from protection of public trust resources, the Board explicitly acknowledged that, "[a] number of alternatives are available to LADWP to help offset water losses from the reduction of Mono Basin exports," including local groundwater, water conservation, water recycling, other surface supplies, and transfers. SWRCB Decision1631 at 165-168. The Board determined that the focus of the economic analysis is whether the economic costs make adoption of the decision feasible, and concluded that neither the water supply nor power supply costs made the protections infeasible and that there would be sufficient water to meet municipal needs of Los Angeles when diversions are restricted. *Id*. at 176-177.

In recent years the Board has mandated improved water use efficiency and other measures as conditions for approving changes to water rights. *See, e.g.,* Order WR 2009-0034-EXEC (Order approving temporary urgency change for Sonoma County Water Agency, which includes conditions limiting irrigation of commercial turf grass (condition #13), establishing water efficiency goals (condition #15), and development of development of water conservation plans (condition #16-17)). The Board has substantial constitutional and statutory authority to establish conditions on the water rights of the CVP, SWP, and other diverters that mandate improved water use efficiency, investments in water recycling and other alternative water supplies, and avoid waste and unreasonable use of water in their service areas. This authority stems from the public trust doctrine, from federal and state statute, from the express conditions on existing water rights, and from the constitutional requirement prohibiting waste and unreasonable use of water. The mandatory terms and conditions included in every water rights license or permit explicitly preserves the Board's authority to require the permittee or licensee to implement a water conservation plan, which may include water recycling or efficiency measures.[3] *See* SWRCB, Mandatory License Terms, available at: http://www.swrcb.ca.gov/waterrights/water_issues/programs/permits/terms/license/mandatory.pdf, last accessed October 11, 2012. While the Board may determine it is unnecessary to include mandatory terms imposing specific conservation, recycling, and

[3] "The continuing authority of the State Water Board may be exercised by imposing specific requirements over and above those contained in this license with a view to eliminating waste of water and to meeting the reasonable water requirements of licensee without unreasonable draft on the source. Licensee may be required to implement a water conservation plan, features of which may include but not necessarily be limited to: (1) reusing or reclaiming the water allocated; (2) using water reclaimed by another entity instead of all or part of the water allocated; (3) restricting diversions so as to eliminate agricultural tailwater or to reduce return flow; (4) suppressing evaporation losses from water surfaces; (5) controlling phreatophytic growth; and (6) installing, maintaining, and operating efficient water measuring devices to assure compliance with the quantity limitations of this license and to determine accurately water use as against reasonable water requirement for the authorized project. No action will be taken pursuant to this paragraph unless the State Water Board determines, after notice to affected parties and opportunity for hearing, that such specific requirements are physically and financially feasible and are appropriate to the particular situation."

other investments in water rights and/or the program of implementation, the Board has authority to do so and has done so in recent years.

This approach also is consistent with the requirements of the 2009 Delta Reform Act. That Act reiterated that, "[t]he longstanding constitutional principal of reasonable use and the public trust doctrine shall be the foundation of state water management policy and are particularly important and applicable to the Delta." Water Code § 85023. Likewise, that Act established co-equal goals of "providing a more reliable water supply for California and protecting, restoring, and enhancing the Delta ecosystem" in a manner that protects and enhances the unique values of the Delta and its communities. Water Code § 85054. And in order to provide a more reliable water supply, the Legislature mandated that,

> The policy of the State of California is to reduce reliance on the Delta in meeting California's future water supply needs through a statewide strategy of investing in improved regional supplies, conservation, and water use efficiency. Each region that depends on water from the Delta watershed shall improve its regional self-reliance for water through investment in water use efficiency, water recycling, advanced water technologies, local and regional water supply projects, and improved regional coordination of local and regional water supply efforts.

Cal. Water Code § 85021.

Finally, the physical solution doctrine also compels the Board to consider alternative water supplies in promoting maximum beneficial use of the State's water resources:

> "In resolving disputes involving competing uses of water, California courts have frequently considered whether there is a "physical solution" available by which competing needs can best be served. (*Peabody v. Vallejo*, 2 Cal.2d 351, 383-384 [40 P.2d 4861 (1935); *City of Lodi v. East Bay Municipal Util. Dist.*, 7 Cal.2d 316 [60 P.2d 4391 (1936).) Adoption of a physical solution is consistent with the constitutional goal of promoting maximum beneficial use of the State's water resources."

SWRCB Decision 1631 at p.10. Under the physical solution doctrine, the Board can require habitat restoration or similar measures to protect public trust resources. *Id*. at 118 ("Thus, as part of a physical solution allowing for diversion of water for municipal use, LADWP can be required to undertake waterfowl habitat restoration measures. Waterfowl habitat restoration can serve to restore public trust uses while requiring a smaller commitment of water.").[4] Equally important, the physical solution doctrine must also include consideration of the development of alternative water supplies, such as conservation and recycling, where such a physical solution can be used to reasonably and feasibly advance protection of public trust resources and the consumptive

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[4] Such measures can be included in the program of implementation, and the obligations can be made enforceable through the water rights proceeding to implement the Plan.

demand for water. The Board has broad authority to require the development of alternative water supplies as a physical solution to reduce conflicts between such uses of water.

Thus, state law requires the Board to consider these alternative supplies in balancing between competing beneficial uses, in determining what measures are "feasible" to protect public trust resources, and in considering a physical solution to protect public trust resources and other beneficial uses of water.

3. The Board's Discretion in Balancing Protections for Public Trust Fishery Resources Has Been Constrained by CESA and other Legislative Enactments

The courts have previously determined that the SWRCB's balancing of competing beneficial uses is constrained by legislative enactments such as sections 5937 and 5946 of the Fish and Game Code, which are specific legislature rules concerning the public trust. *California Trout, Inc. v. State Water Resources Control Bd.*, 207 Cal.App.3d 585, 622-625, 631 (1989); *California Trout, Inc. v. State Water Resources Control Bd*., 218 Cal.App.3d 187, 195 (1990). According to the Court of Appeal, in its 1989 decision, "[w]e concluded that, by the enactment of section 5946, the Legislature had resolved the competing claims for the beneficial use of water in these streams in favor of preservation of their fisheries." *California Trout, Inc.*, 218 Cal.App.3d at 195; *see also* SWRCB Decision 1631 at 12. While the court recognized that the legislature's authority was not unlimited and was subject to the constitutional limitations of reasonable use, the court recognized that the legislature has substantial authority to define the balance between competing beneficial uses. *California Trout, Inc.*, 207 Cal.App.3d at 625. Subsequently, the Board explicitly found that compliance with section 5937 and 5946 of the Fish and Game Code is not subject to balancing, concluding that these protections are mandatory and that, "[f]lows needed to reestablish and maintain the fishery are not subject to reduction due to economic cost." SWRCB Decision1631 at 172.

The Legislature has similarly resolved the question of balancing in favor of protecting threatened and endangered species under the California Endangered Species Act ("CESA").[5] Among competing beneficial uses, the legislature has afforded priority for protecting species listed under CESA, and the legislature has required state agencies to act to conserve listed species and to prevent their extinction. Fish and Game Code §§ 2050 et seq; *see esp. id*. §§ 2052, 2053, 2055. In past water rights decisions, the Board has recognized that CESA requires the Board to act to conserve listed species: "Thus, in exercising authority over water rights in the lower Yuba River, the California Endangered Species Act **requires** the SWRCB to seek to conserve spring-run Chinook salmon." SWRCB Decision 1644 at p. 27 (emphasis added).[6] As with section 5937, in

[5] As discussed infra, the Legislature has also expressed the primacy of protecting salmon in enacting the salmon doubling requirement in 1989 as part of the Salmon, Steelhead Trout, and Anadromous Fisheries Program Act. Cal. Fish and Game Code §§ 6900 *et seq*.
[6] In addition, applicants for water rights and for permits to change the point of diversion, purpose of use, or place of use must demonstrate compliance with the federal endangered species Act and the requirements of the Fish and Game Code. Cal. Water Code §§ 1275(b), 1701.3(b)(2).

enacting CESA the legislature has "resolved the competing claims for the beneficial use of water in these streams in favor of preservation of their fisheries." *See California Trout, Inc.*, 218 Cal.App.3d at 195. The Board lacks authority to disregard that rule. *California Trout, Inc.*, 207 Cal.App.3d at 631 ("We agree with the Water Board that the mandate of section 5946 is a specific legislative rule concerning the public trust. Since the Water Board has no authority to disregard that rule, a judicial remedy exists to require it to carry out its ministerial functions with respect to that rule. The Legislature, not the Water Board, is the superior voice in the articulation of public policy concerning the reasonableness of water allocation.").

While some may argue that Water Code section 106 establishes an absolute priority for municipal uses of water, the Supreme Court has acknowledged that "these policy declarations must be read in conjunction with later enactments requiring consideration of in-stream uses (Wat. Code, §§ 1243, 1257, quoted ante at pp. 443-444) and judicial decisions explaining the policy embodied in the public trust doctrine. Thus, neither domestic and municipal uses nor in-stream uses can claim an absolute priority." *National Audubon Society*, 33 Cal. 3d at 448 n. 30. The Supreme Court did not address the priority afforded to resource protection under CESA in *National Audubon Society*, but has elsewhere acknowledged CESA's priority:

> Bay–Delta ecosystem restoration to protect endangered species is mandated by both state and federal endangered species laws, and for this reason water exports from the Bay–Delta ultimately must be subordinated to environmental considerations. The CALFED Program is premised on the theory, as yet unproven, that it is possible to restore the Bay–Delta's ecological health while maintaining and perhaps increasing Bay–Delta water exports through the CVP and SWP. If practical experience demonstrates that the theory is unsound, Bay–Delta water exports may need to be capped or reduced.

In Re Bay-Delta Programmatic Environmental Impact Report Coordinated Proceedings, 43 Cal.4th 1143, 1168 (2008). Unfortunately, the past decade has made clear that this theory was unsound, existing CESA and ESA permits require substantial additional protections for listed species, and the Board has already determined that, "The best available science suggests that current flows are insufficient to protect public trust resources." SWRCB 2010 at 2.

In addition, the Bay-Delta Plan must also meet the requirements of the federal Clean Water Act. Federal regulations under the Clean Water Act require that states must adopt water quality criteria which protect designated uses, and "[f]or waters with multiple use designations, the criteria shall support the most sensitive use." 40 CFR § 131.11(a).[7] This federal regulation also precludes the Board from failing to provide adequate protections for listed native fish species in

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[7] In addition, in reviewing the Bay-Delta Plan EPA must consult with the U.S. Fish and Wildlife Service and National Marine Fisheries Service under section 7 of the Endangered Species Act. As a result, the Plan must avoid jeopardy to federally listed species and be consistent with protections afforded to federally listed species

the Delta (the Preservation of Rare, Threatened, or Endangered Species (RARE) beneficial use in the 2006 Bay-Delta Plan), which is typically the most sensitive use.

As a result, the Board must at a minimum adopt flow and other objectives in the Bay-Delta Plan that are consistent with the conservation of listed species under CESA. But the Board should achieve more than minimal compliance with CESA, both with respect to listed species as well as to provide adequate protection for species, such as fall run Chinook salmon, that are not listed under CESA but support major commercial and recreational fisheries and/or are species of concern whose populations have declined over time. This is consistent with the co-equal goals of the Delta Reform Act, the public trust doctrine, and salmon doubling requirements; the co-equal goals do not preempt, override, or affect CESA, the Fish and Game Code, the Porter-Cologne Water Quality Control Act, section 1702 of the Water Code, the public trust doctrine, CEQA, water rights, or several other enumerated laws. Cal. Water Code § 85032.[8] Instead, the co-equal goals make restoration of fish and wildlife beneficial uses in the Delta of equal concern to improving water supply reliability.

4. <u>The Board Must Consider Economic Benefits of Protecting Public Trust Fishery Resources in Determining the Reasonableness of Water Quality Objectives</u>

As the Board considers economic factors and other beneficial uses in determining what objectives to protect fish and wildlife beneficial uses in the Bay-Delta are reasonable, Cal. Water Code § 13241, and what protections for public trust resources are feasible, *National Audubon Society,* 33 Cal.3d at 446, the Board cannot limit its analysis to economic costs, but must also consider the economic benefits of improved flows for public trust resources. These economic benefits include:

- The economic value of sustaining and restoring commercial and recreational fisheries for salmon, crab, starry flounder, sturgeon, and numerous other native species that depend upon the Delta. Together, these fisheries contribute at least hundreds of millions of dollars each year to local and state economies and support thousands of jobs.
- The economic value of recreational activities in the Delta, such as bird watching or duck hunting, which depend upon a healthy Delta ecosystem. In 2011, the U.S. Fish and Wildlife Service estimated that 26% of Californians participated in hunting, fishing, or wildlife dependent recreation (such as birdwatching), and that statewide, these activities resulted in more than $7 billion in total expenditures. The Board should invite the Delta Protection Commission, other local and state agencies, and other economists to provide detailed information and estimates of the economic value of wildlife dependent recreation in the Delta.
- The monetary value of a healthy Delta ecosystem, including recovery of listed fish species. David Sunding has presented preliminary results of a contingent valuation methodology for the Bay Delta Conservation Plan, which showed that the non-use value of restoring the Delta ecosystem ranges from a present value of $12 billion to $53

[8] The Delta Reform Act also explicitly preserves area of origin, watershed of origin, water rights priorities, and several other provisions of the water Code. Cal. Water Code § 85031.

billion.[9] His analysis shows that the present non-use value of restoring the Delta is greater than the present value of a 20% reduction in water exports from the Delta, and may be worth three times as much as a 20% reduction in water exports from the Delta. Given the importance of adequate flows to restoring the health of the Delta ecosystem, these estimates should apply equally to the Board's weighing of economic benefits of improving flow conditions in the Bay-Delta.

- The economic value of agriculture in the Delta, to the extent that protections for fishery resources are consistent with and help protect agricultural uses in the Delta.
- Improved reliability of water supplies over the longer term in terms of reduced conflicts with species protections and avoiding future endangered species act listings.
- Other economic values that are consistent with ecosystem protection of the Delta, such as the value of protecting export water quality (reduced water quality treatment costs).

Of course, economic considerations do not trump the responsibility to protect public trust resources or meet other legal requirements. *See* Brian Gray, *Ensuring the Public Trust*, 45 U.C. Davis L. Rev. 973, 990 ("if the consumptive use threatens significant harm to public trust uses, the public trust may take precedence — even at substantial cost to the consumptive water user." (citations omitted)); SWRCB Decision 1631 at 176-180 (increased costs of developing alternative water supplies was feasible and did not prevent implementation of protection of public trust resources). As the Board concluded in 1994, the focus is in determining "whether the economic costs of this decision [to protect public trust resources] make its adoption infeasible." SWRCB Decision1631 at 176-77. And where the legislature has acted to constrain the Board's discretion, the Board has recognized in past decisions that economic considerations cannot outweigh meeting those statutory mandates. SWRCB Decision 1631 at 172; *see* pages 7 through 9, *infra*. This is particularly true when a physical solution, such as the development of water recycling facilities or improved water use efficiency, is feasible and minimizes conflicts between protection of public trust resources and other beneficial uses of water.

5. <u>The Water Quality Control Plan and Program of Implementation Must Demonstrate How Salmon Doubling and Other Objectives Will be Achieved</u>

Under state law, the Board must determine what flows and other actions are necessary to achieve salmon doubling and other water quality objectives that are adopted in the Bay-Delta Plan. Water Code §§ 13050(j)(3), 13242(a); *In re State Water Resources Control Board Cases*, 136 Cal.App.4th 674, 775 (2006) ("Determining what actions were required to achieve the narrative salmon protection objective was part of the Board's obligation in formulating the 1995 Bay–Delta Plan in the first place.").

For more than two decades, both state and federal law have required the State and Federal governments to take action to double natural production of native salmon populations. Cal. Fish

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[9] Sunding's analysis is available online at: http://baydeltaconservationplan.com/Files/June%202012%20Public%20Meeting%20Presentation%206-20-12.pdf (*see* slides # 51-54).

and Game Code §§ 6900 *et seq*; Central Valley Project Improvement Act, § 3406(b)(1) of P.L. 102-575. Consistent with these statutory requirements, the 1995 Bay-Delta Plan included a narrative objective of salmon doubling, which reads: "Water quality conditions shall be maintained, together with other measures in the watershed, sufficient to achieve a doubling of natural production of Chinook salmon from the average production of 1967-1991, consistent with the provisions of State and federal law." In the 1995 Plan, and again in the 2006 Plan, the State Board recognized that non-flow measures could contribute to meeting the salmon doubling objective, and in the 2006 Plan the Board identified several such measures.

In the 1995 Plan, the Board acknowledged uncertainty as to whether the measures would be sufficient to achieve the objective, and in the 2006 Plan the Board found that "D-1641 did not require separate actions to implement the narrative objective for salmon because the State Water Board expects that implementation of the numeric flow-dependent objectives and other non-flow measures will implement this objective." 2006 Plan at 33. In both plans, the Board stated that monitoring results and studies would be used to evaluate achievement of this objective and to develop additional or revised numeric objectives. 1995 Bay-Delta Plan at 29; 2006 Plan at 33.

Unfortunately, it is clear that the specific flow objectives in the plan and those other measures were not sufficient to achieve the salmon doubling objective, as salmon populations have continued to decline and are further from achieving the doubling goal than when the CVPIA was enacted twenty years ago. While salmon doubling will not be achieved solely by improving flow conditions, there is substantial evidence that the existing flow requirements in the 2006 Plan are not sufficient to achieve salmon doubling. As a result, the Board must ensure that the updated plan and program of implementation include flow and other measures that will achieve salmon doubling. As the Court of Appeal noted in 2006,

> If the Audubon Society parties are correct in their contention that scientific evidence shows the flows needed to achieve the narrative salmon protection objective must be greater than the Vernalis flow objectives of the 1995 Bay–Delta Plan, then that evidence may provide a basis for *changing* the Vernalis flow objectives in the next regulatory proceeding to review and revise the water quality control plan for the Bay–Delta.

In re State Water Resources Control Board Cases, 136 Cal.App.4th at 777. There is sufficient scientific evidence showing that greater flows and other protections are needed to achieve the narrative salmon doubling objective, in terms of Vernalis inflow as well as Sacramento River inflow, outflow, and cross-delta flows / export restrictions.

6. Conclusion

The Board faces substantial challenges in meeting its responsibility to preserve fish and wildlife beneficial uses, protect the public trust, conserve endangered fish species and commercial and recreational fisheries, double salmon populations, and contribute to more reliable water supplies by investments in water recycling, conservation, and other regional tools. But the Board also has a significant opportunity before it, to place California on a path to restoring one of the largest and most unique estuarine ecosystems in the world to some measure of health and resilience and on a path to creating a more sustainable water supply that can support a growing population and economy. Finally, the Board has substantial authority to realize these goals, and a legal and ethical mandate to wield that authority. We look forward to working with the Board to ensure that the Bay-Delta Plan achieves these legal requirements and protects public trust resources, and the jobs, economies, and quality of life that depend on them.

II. Recommendations Relating to Workshop 3: Analytical Tools for Evaluating the Water Supply, Hydrodynamic, and Hydropower Effects of the Bay-Delta Plan

This section directly addresses the two major questions posed as topics for discussion in Workshop 3:

- What types of analysis should be completed to estimate the water supply, hydrodynamic, and hydropower effects of potential changes to the Bay-Delta Plan? and
- What analytical tools should be used to evaluate those effects?

Our recommendations are focused on the tools and analytical components the Board should consider in an impact analysis of potential changes to the Plan that can be done in a relatively short period of time (i.e., in order to support adopting Plan amendments by mid-2014) and which best reflect the many adaptations that water users and hydropower producers can and will employ in response to new requirements and a changing climate. While there are a number of models and tools that the Board should consider, the Board should be aware of and work to address the limitations of these models, particularly ones that were developed to address questions very different from the ones being asked by the Board. Even though time constraints may force the Board to employ monthly models that are sub-optimal for the task, no one model should be relied upon for the water supply impact. The Board should consider employing screening models, simulation and optimization models, as well daily or weekly spreadsheet-based models.

1. <u>Evaluate Alternative Water Supplies and Incorporate Them Into the Modeling of Changes to the Bay-Delta Plan</u>

The Board should analyze the full range of water supply management tools including water recycling, improved conservation and efficiency, conjunctive use, transfers, etc., that water users could use to adapt to and mitigate the impacts of changing circumstances, including new Plan requirements. These water supplies and management options should be incorporated into the modeling to fully assess the impacts of changes to the Plan.

a. Increased Investments in Water Efficiency, Recycling, and Other Alternative Water Supply Strategies and Tools Can Yield Significant New Water

Increased water use efficiency, alternative water supplies, and smarter water management offer substantial opportunities to increase California's water supply and decrease demands for water diversions from the Bay-Delta. Based on statistics from the Department of Water Resources' 2009 State Water Plan and supporting documents, documents produced by the State Water Resources Control Board, and research conducted by NRDC and the University of California, Santa Barbara, alternative water supplies and water use efficiency could conservatively result in an additional 6.12 million acre-feet of water per year, state wide, by the year 2030. Based on the conservative estimates outlined below, alternative water supplies could produce significantly more water than current average diversions from the Sacramento-San Joaquin Delta. These alternative water supplies come in the form of agricultural water use efficiency, urban water use efficiency, groundwater, recycled water, and urban stormwater capture (also referred to as low impact development), and in many cases can be more cost effective and more reliable in the long term than Delta supplies. Below we identify additional information and resources for the Board's update of the Bay-Delta Plan.

i. Agricultural Water Use Efficiency

According to CALFED's 2006 Water Use Efficiency Comprehensive Evaluation, on-farm and water supplier recoverable and irrecoverable flow reductions could range from .33 million acre-feet to 3.96 million acre-feet by 2030, depending on investments and funding.[i] In terms irrecoverable flows, CALFED estimates that flow reductions could range from .034 to .888 million acre-feet per year. CALFED estimates that regulated deficit irrigation flow reductions will be 0.142 million acre-feet. In the 2009 State Water Plan Update, DWR chose to use an annual irrecoverable flows water savings of .888 million acre-feet per year for planning purposes. Combined with regulated deficit irrigation flow reductions that yields an annual savings of 1.03 million acre-feet per year. In addition to DWR's estimates, others have estimated significantly higher potential water savings from improved agricultural water use efficiency.

ii. Urban Water Use Efficiency

Urban water use efficiency has the potential to greatly reduce demand for Delta water.[ii] The state estimates that potential reductions in demand from SB 7x7 compliance alone are 1.59 million acre-feet annually by 2020. According to a 2006 CALFED evaluation, the total annual technical potential for 2030 urban water savings is about 3.1 million acre-feet per year. This technical potential does not include advances in water-saving technology, which could lead to even higher levels of efficiency savings.[iii] Los Angeles Department of Water estimates that the unit cost for conservation is in the range of $75-900 per acre-foot, depending on the costs of conservation rebates, hardware installation, and incentive programs and their potential water reductions.[iv] Inland Empire Utilities Agency estimates that their conservation programs cost $69-1094 per acre foot.[v]

iii. Urban Stormwater Capture

A technical analysis conducted by NRDC and UCSB found that implementation of low impact development practices that emphasize rainwater harvesting has the potential to increase local water supplies by up to 405,000 acre-feet of water per year by the year 2030.[vi] Expanding the use of low impact development to industrial, government, public use, and transportation development and redevelopment in southern California has the potential to yield an additional 75,000 acre-feet of savings per year by 2030. Low impact development is a cost-effective alternative water supply – the U.S. Environmental Protection Agency states that "LID practices can reduce project costs and improve environmental performance" of development and that, with few exceptions, low impact development has been "shown to be both fiscally and environmentally beneficial to communities."[vii] According to the State Water Resources Control Board's Recycled Water Policy, the State Board has adopted the goal of increasing the use of stormwater over 2007 use by at least 0.5 million acre-feet per year by 2020, and at least one million acre-feet per year by 2030.[viii] Los Angeles Department of Water and Power has estimated that the unit costs of advanced urban runoff management range from $60 per acre-foot for centralized stormwater capture, to $4,044 per acre-foot for urban runoff plants. LADWP estimates that the cost of rain gardens ranges from $149-1,781 per acre foot, and water from rain barrels and cisterns ranges in cost from $2,326 to $2,788 per acre foot.[ix]

iv. Recycled Water

DWR's 2009 State Water Plan Update estimates that 0.9 million to 1.4 million acre-feet of "new water" could be created by 2030 by recycling municipal wastewater that is discharged into the ocean or saline bays. Statewide, there is an estimated potential supply of about 1.85 to 2.25 million acre-feet of water that could be realized by the year 2030.[x] The State Board has adopted a recycled water use target of at least one million acre-feet per year by 2020, and at least two million acre-feet per year by 2030.[xi] When considering both capital and O&M costs to expand Los Angeles Department of Water and Power's recycled water system to achieve water recycling targets, LADWP estimates that the present value per acre-foot of recycled water over a 50-year life cycle analysis results in a blended cost of $1,100 per acre-foot.[xii] A sampling of the operational costs of the existing recycled water projects in San Diego County show costs ranging from $1,259-1,662 per acre-foot.[xiii] The unit cost of the current Orange County Water District Groundwater Replenishment indirect potable reuse water is $1,299 per acre-foot, including the cost of extraction.[xiv] In addition to municipal wastewater recycling, recycling of a variety of waste streams, including brackish groundwater, agricultural drain water, produced oil water, and municipal greywater, can significantly increase the water supplies in the Central Valley and export regions..

v. Conjunctive Groundwater Management

According to DWR's 2009 State Water Plan Update, conservative estimates of additional implementation of conjunctive management of groundwater resources indicate the potential to increase average annual water deliveries by 0.5 million acre-feet throughout the state. More ambitious estimates indicate the potential to increase average annual water deliveries by two million acre-feet per year.[xv]

b. The Board Should Consider Alternative Water Supply Strategies and Tools in Evaluating Potential Water Supply, Economic and Employment Consequences of Changes to the Plan

The existing CALSIM model is a monthly simulation model to evaluate Federal and State export capabilities, and is designed to meet all demands no matter what the cost, subject to regulatory and physical constraints. It is not the optimal tool for assessing potential water supply impacts in light of alternative water supply strategies such as intra-Basin water transfers, improved water use efficiency, water recycling, and increased groundwater use. The Board should take great care using CALSIM results in estimating water supply impacts, and the use of those results in subsequent modeling of economic and employment effects, such as the Statewide Agricultural Production (SWAP) model or Impact Analysis for Planning (IMPLAN) model. Deficiencies in the water supply modeling will propagate through subsequent economic models.

By ignoring the many alternative and adaptive water management strategies available to water users, modeling can result in significant overestimates of impacts. For instance, initial IMPLAN modeling of employment and economic effects of drought and fishery protection measures in 2009 were dramatically revised downward (employment estimates were revised downward by an order of magnitude), in large part because of increased water transfers which were not anticipated in the modeling. Jeffrey Michael and Richard Howitt et al 2010. *A Retrospective Estimate of the Economic Impacts of Reduced Water Supplies to the San Joaquin Valley in 2009*, at 1.

The Board has acknowledged this conclusion in other analyses; for instance, as the Board has recognized in February 2012, "Input-output analysis approach employed by IMPLAN usually overestimates indirect job and income losses…. For these and other reasons, job and income losses estimated using input-output analysis should often be treated as upper limits on the actual losses expected (SWRCB 1999)." *See* SWRCB, Draft Agricultural Economic Effects of Lower San Joaquin Flow Alternatives, February 2012, at X-29.

Over the longer term, because of availability of alternative supply tools (and greater price elasticity of water in the longer term), estimates of employment and economic consequences of reduced Bay-Delta diversions will likely be overestimated. This is consistent with observed behavior during drought and in prior proceedings, where water users have utilized water transfers, improved efficiency, and other alternative supplies when diversions were reduced.

Therefore, the Board should also consider using water supply models, such as UC Davis' CALVIN model,[10] which can incorporate the response of water users to reduced diversions from the Bay-Delta, including investments in conservation, water recycling, and other alternative water supply tools, as well as increased water transfers. In addition, the Board should explicitly acknowledge in its analysis that estimates of the economic and employment consequences of changes in water supply are likely to be overestimated to the extent that feasible increases in conservation, water transfers, and alternative water supplies are not explicitly modeled.

2. <u>The Board Should Explicitly Model Reservoir Reoperation and Include Changed Assumptions in CALSIM Modeling, Which Has Demonstrated that Increased Spring Outflow Need Not Adversely Affect Upstream Reservoir Storage</u>

[10] University of California, Davis. Statewide Economic-Engineering Water Model – CALVIN. Available online at: http://cee.engr.ucdavis.edu/faculty/lund/CALVIN/ (last visited October 22, 2012).

As the Board recognized in the September 6, 2012 workshop, CALSIM modeling work in BDCP on Alternative 8 shows that increased winter/spring outflow need not adversely affect upstream reservoir storage (cold water pool) and upstream protections necessary for spawning and juvenile salmonids. As the Board is well aware, one of the significant limitations of the CALSIM model is that it typically does not include reservoir carryover requirements in the model and the model is driven to maximize CVP/SWP exports within available constraints. We understand that the state and federal agencies working on BDCP developed additional modeling of reservoir reoperation criteria in 2012 (part of the CS5 modeling), which included revised reservoir storage and release criteria to protect salmonids.

The Board should build on and further refine the approach to modeling Alternative 8 and CS5, in consultation with the fish and wildlife agencies, to explicitly model revised reservoir reoperation criteria and account for minimum reservoir storage and releases needed to meet downstream temperature compliance points in the spring and summer months. This revised modeling analysis should be applied to a broader range of alternative outflow objectives in this proceeding, and should be utilized to ensure that the Plan includes both adequate inflow and outflow requirements, while also ensuring that upstream protections for salmonids are maintained or enhanced, particularly in the face of climate change.

3. <u>The Board Must Incorporate Climate Change in its Modeling and Analysis of Consequences of Potential Changes to the Plan</u>

Because climate change is likely to alter the timing and volume of runoff into the Bay-Delta, the Board must incorporate the effects of climate change into its analysis. Recent modeling work performed for the California Energy Commission has demonstrated that climate change is likely to dramatically change the frequency of water year types as defined in D-1641; as the authors noted, “If current water year type thresholds are maintained, more years will be classified as dry and less water will be allocated for environmental outflows, perhaps failing to provide adequate hydrologic variability to support species, habitats, and ecosystems.” Null & Viers 2012 at ii. Their modeling predicts that the effects of climate change will generally result in reduced annual runoff and April-Jul Runoff in both the San Joaquin and Sacramento Basins in the 2001-2050 period as compared to 1951-2000. *Id*. at 8-9. As a result, in the Sacramento Basin their model generally predicts that critical and dry water year types will be more frequent, and above normal and wet years will be less frequent. *Id*. at 15. For the San Joaquin Valley, the results are even more striking, with as much as a 15% increase in critical water year types (to over 41% of years), and reductions in all other water year types. *Id*.

Similarly, DWR’s modeling (including sea level rise) also anticipates that water exports from the Bay-Delta will decrease as a result of climate change; for instance, modeling for BDCP anticipates that the effects of climate change will reduce water exports by 200TAF by 2025. The effects are even more dramatic over the longer term, with DWR predicting that water exports from the Bay-Delta may decrease by 10% by 2050 and by 25% by 2100 as a result of climate change. *See* DWR, Possible Impacts of Climate Change to California's Water Supply, California Climate Center, Summary Sheet, April 2009 (Available at: http://www.water.ca.gov/pubs/climate/climate_change_impacts_summary_sheet__june_2009/climate_change_impacts_summary_sheet_6-12-09_lowres.pdf).

We strongly encourage the Board to incorporate climate change effects, including these analyses, into their modeling of the analysis of the consequences of potential changes to the Plan. In particular, because the modeling shows that the frequency of water year types is likely to change significantly, we strongly encourage the Board to move away from objectives and flow measures that are based on water year type, and instead use a percentage of unimpaired flow approach or similar tool. Objectives based on water year type will become less protective of public trust resources as a result of climate change.

4. If the Board uses the CALSIM model for impact assessment, it should use CALSIM 3 as it represents a more transparent and better documented model than CALSIM 2, provides a superior representation of the hydrology and water use, and can more readily evaluate some alternative water management strategies.

Although the use of the CALSIM simulation for impact assessment has the shortcomings noted above (including its inability to economically evaluate investments in alternative water management strategies, its formulation as an export demand driven tool for the State and Federal projects which constrains its use as an impact assessment tool for all water users, and the difficulty in easily incorporating different operational strategies), we recognize that it may be used by the Board because it is the most detailed simulation model of the Bay-Delta water supply system and widely used in many other proceedings. Because the CALSIM 2 model is more than a decade old, aggregates water use over large areas, relies on some very outdated 50-year-old hydrologic representations, and is not dynamically integrated with groundwater, efforts were undertaken in the mid-2000s to develop CALSIM 3. That effort is very close to being completed (possibly by the end of 2012) and should provide a much better model than CALSIM 2 for the Board to use, particularly in its superior representation of the hydrology, water use, surface and groundwater interaction, and ability to more readily evaluate changes in land use and irrigation efficiencies. It is also much more transparent and better documented than CALSIM 2 (Andy Draper, personal communication).

5. <u>The Board's Analysis of Unimpaired Flow Alternatives Must be Compared to Disaggregated Flow Needs of Key Species and Public Trust Resources</u>

Finally, as the Board develops alternatives, including alternatives based on a percentage of unimpaired flows, it is critically important that the Board compare the flows likely to be provided under those alternatives against the flow needs of key species and flow recommendations, including those provided by state and federal fish and wildlife agencies. It is not sufficient that the Board simply show that the flow objectives mimic "natural" flows or provide a more natural hydrograph. Rather, the Board must provide analysis showing the likely flows that would be provided under various alternatives and how those compare to fishery needs (duration, frequency, magnitude, and timing of flows).

In order to provide that needed analysis, we recommend the following approach, which is similar to the Board's analysis in 2010. First, the Board should identify the duration, frequency, magnitude, and timing of flows necessary for key species. During the 2010 Delta public trust flow criteria proceedings, we provided specific, detailed flow recommendations targeted to attributes of viability for key species in the ecosystem that are based on publicly available data from agency sampling programs. Based on additional analysis and refinement of our recommendations since 2010, we intend to provide the Board in the near future with a modestly revised set of flow criteria for consideration and potential adoption as water quality objectives in the Plan, along with recommended actions for inclusion in the program of implementation. For the time being, we provide page references to the specific recommendations in our 2010 Delta flow criteria exhibits and 2012 Phase 2 workshop testimony (Table 1); we note also that CDFG and CSPA offered specific flow recommendations in their 2010 testimony to the Board – those recommendations should also be incorporated into the Board's analysis of alternatives.

Table 1: Specific flow recommendations resulting from TBI et al. Exh. 1-4 (2010) and TBI/NRDC (2012) analyses of the relationship between seasonal freshwater flows and attributes of viability for key public trust resources.

Source	**Flow Category**	**Page #**	**Comment**
TBI et al (2010), Ex. 2	Delta outflows (winter spring)	25	Text at bottom of page
TBI et al (2010), Ex. 2	X2 (Fall)	35	Table 1
TBI et al (2010), Ex. 3	Sacramento River Inflow	36	Table 3 (and associated text)
TBI et al (2010), Ex. 4	Hydrodynamic criteria for Sacramento Basin Chinook salmon & steelhead	10	Text
TBI et al (2010), Ex. 4	Hydrodynamic criteria for San Joaquin Basin Chinook salmon & steelhead	12, 23	Text
TBI et al (2010), Ex. 4	Hydrodynamic criteria for Delta smelt	15, 26	Text
TBI/NRDC (2012)	Hydrodynamic criteria for Longfin smelt	22	Footnote 10 (correcting typographical error in TBI et al 2010, Exh. 4)
TBI et al (2010), Ex. 4	Hydrodynamic criteria for maintenance of protective spatial distribution (multiple species)	29	Text
Note: We summarized our hydrodynamic recommendations in TBI et al., Exh. 4, p. 30 (Table 1). For the Board's convenience, we converted all hydrodynamic flow recommendations into their rough equivalent in terms of Old and Middle River flows (using interpolations described earlier in the exhibit). For the Board's current analysis, we recommend analyzing hydrodynamic criteria in the terms (e.g. Vernalis Flow:Export Ratio, etc.) in which they were originally developed in our testimony. Also, please note that the footnote associated with April and May of critical years has been corrected in our Workshop 2 testimony (page 22, footnote 10).			

The Board should aggregate these flow needs into an annual hydrograph and then compare that aggregated analysis with flow alternatives that express actual flows as a continuous function of unimpaired hydrology to determine the extent to which alternatives achieve the duration, frequency, magnitude, and timing of flow recommendations for key species. In its 2010 final report, the Board staff expressed actual recommended flows as a percentage of the 14-day moving average of unimpaired hydrology in the relevant watershed – we support that approach within boundaries established by requirements for maintaining upriver storage described in the NMFS Biological Opinion (NMFS 2009) and minimum exports required to protect human health and safety.

Because many of our flow recommendations fall along a somewhat continuous spectrum of benefits to public trust resources (i.e., they are not binary, full benefit v. no benefit at all), and because all of our recommendations are based on the assumption that *all other significant non-flow related stressors are addressed*[11], we recommend that Board staff evaluate the potential benefits of different levels of freshwater flow using a tabular approach as outlined below in Table 2.

Table 2: Recommended approach to capturing differences among flow alternatives in their ability to provide flows necessary to support viability of public trust benefits. For each specific flow criteria recommendation (e.g. from TBI et al. Ex. 1-4, 2010, CDFG 2010), modeling would determine each flow alternative's ability to provide the recommended flow in terms of its magnitude, timing, duration, and frequency or fraction thereof if other aspects of flow were attained as recommended.

Flow Alternative	**Criteria Based On** **(Species -- Attribute)**	**Location**	**Max % Magnitude** **(*if* timing, duration, & frequency as originally described)**	**Max % Timing** **(% of critical period *if* mag., dur., freq. as originally recommended)**	**Max % Duration** **(*if* mag., timing, & freq. as originally recommended)**	**Frequency** **(*if* mag., timi & duration a originally recommende**

[11] As stated in our 2010 testimony: "In developing flow criteria we have recommended the *minimum* flows required to restore the viability of public trust species *if all other stressors are appropriately mitigated*." TBI et al. 2010; Exh. 1, p. 15. Emphasis in original.

This approach will allow the Board to determine which viability attributes of key aquatic species may be impaired under different flow alternatives and where there are tradeoffs between aspects of flow (magnitude, duration, timing, and frequency). This will facilitate efforts the Board's efforts to balance public trust values against other beneficial uses and to identify the extent to which different flow alternatives satisfy (or fail to satisfy) the needs of public trust resources.

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[i] http://www.waterplan.water.ca.gov/docs/cwpu2009/0310final/v2c02_agwtruse_cwp2009.pdf
[ii] 20x202 Water Conservation Plan. February 2010. http://www.swrcb.ca.gov/water_issues/hot_topics/20x2020/docs/20x2020plan.pdf
[iii] http://www.waterplan.water.ca.gov/docs/cwpu2009/0310final/v2c03_urbwtruse_cwp2009.pdf
[iv] Los Angeles Department of Water and Power UWMP page 22
[v] IEUA 2010 Water Use Efficiency Business Plan, Page 62
[vi] A Clear Blue Future: How Greening California Cities can Address Water Resources and Climate Challenges in the 21st Century. NRDC Technical Report, August 2009. By Noah Garrison (NRDC) and Robert C. Wilkinson (Donald Bren School of Environmental Science and Management, University of California at Santa Barbara) http://www.nrdc.org/water/lid/files/lid_hi.pdf
[vii] U.S. Environmental Protection Agency, December 2007, Reducing Stormwater Costs through Low Impact Development (LID) Strategies and Practices, fact sheet number 841-F-006, http://www.epa.gov/owow/nps/lid/costs07/factsheet.html
[viii] State Water Resources Control Board Recycled Water Policy Preamble, Page 1 http://www.swrcb.ca.gov/water_issues/programs/water_recycling_policy/docs/recycledwaterpolicy_approved.pdf
[ix] Los Angeles Department of Water and Power UWMP Page 22
[x] http://www.waterplan.water.ca.gov/docs/cwpu2009/0310final/v2c11_recycmuniwtr_cwp2009.pdf
[xi] http://www.swrcb.ca.gov/water_issues/programs/water_recycling_policy/docs/recycledwaterpolicy_approved.pdf
[xii] Personal communication with Los Angeles Department of Water and Power, Thomas Erb and James Yannotta, by NRDC intern Caitrin Phillips. http://switchboard.nrdc.org/blogs/bnelson/Local%20vs%20Imported_Final%208-4-11.pdf
[xiii] SDCWA Unit Cost of New Local Supply Alternatives, September 15, 2010
[xiv] SDCWA Unit Cost of New Local Supply Alternatives, September 15, 2010
[xv] http://www.waterplan.water.ca.gov/docs/cwpu2009/0310final/v2c08_conjunctmgmt_cwp2009.pdf

III. Closing Comments, Part Two: Discussion of Selected Issues Raised in the Phase 2 Workshops

1. As the Board Appropriately Concluded in 2010, there is Sufficient Scientific Information on Which to Improve Flows to Protect Public Trust Resources

Contrary to the suggestions of some participants at the prior two workshops, the Board has sufficient scientific information on which to base changes to the Bay-Delta Plan in order to adequately protect public trust resources and achieve other statutory requirements. Only two years ago, the Board concluded that there was sufficient scientific information on which to act to increase flows: "There is sufficient scientific information to support the need for increased flows to protect public trust resources; while there is uncertainty regarding specific numeric criteria, scientific certainty is not the standard for agency decision making" (SWRCB, 2010, p. 4). That Board finding is still accurate today, and as documented in our testimony for workshops 1 and 2, the new scientific information developed since 2010 largely confirms and strengthens the conclusions in the Board's 2010 report.

The Bay-Delta is one of the best-studied estuaries in the world, with an incredible set of long term monitoring data and targeted scientific studies. Although there will always be scientific uncertainty and a need for managing adaptively as new information becomes available, the best available scientific information demonstrates that current flows are completely inadequate to protect public trust resources. The situation is urgent: 83% of California's fish species are extinct or at risk of becoming so (TU et al, 2012). Scientific uncertainty does not justify failing to act, as the Delta Environmental Flows Group reminded the Board in 2010 (Delta Environmental Flows Group, 2010). Instead, the Board should:

- Set water quality objectives based on the best scientific information that is currently available.
- Articulate clear and measurable biological and ecological targets that represent the desired outcomes of implementing the objectives.
- Identify specific scientific studies or monitoring programs that are necessary to help reduce scientific uncertainty.
- Use an adaptive management program to modify flow levels (and/or utilize the Board's next review of the Plan to revise objectives in light of new scientific information).

2. The Need to Address Other Stressors Does Not Reduce the Need for Large-Scale Flow Augmentation; Indeed, Improving Flows Is Critical to Addressing Other Stressors

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Some parties have suggested during the Phase 2 workshops that the Board's update to the Plan will necessarily be deficient because it only addresses flow alteration, and that mitigating the impacts of other stressors is more important than improving flow conditions. These assertions are quite simply incorrect.

a. The scientific evidence clearly demonstrates that flow alteration is the single most important, best-documented stressor of fish and wildlife beneficial uses, and that restoring flows is most likely to be effective in protecting those uses.

Following the large-scale conversion of natural habitats that occurred in the late 19^{th}/early 20^{th} century, the alteration of freshwater flow rates and timing caused by water storage, diversions and exports since the mid-20^{th} Century is the single most important stressor on fish and wildlife beneficial uses (e.g. Baxter et al, 2007). Half or more of the water that would normally flow through the Delta is diverted by water users upstream and south of the Delta (e.g. Fleenor et al. 2010; Cloern and Jassby 2012); to serve seasonal water use demands, the timing of freshwater flows has been changed dramatically (e.g. Fleenor et al. 2010) and in ways that do not support the evolved life histories of native fishes. The relationship between abundance and distribution of native fish species and the volume, timing and duration of freshwater flows into, through, and/or out of the Delta are

- Powerful (occur over orders of magnitude),
- Persistent (over 4+ decades of community sampling),
- Widespread (including a wide variety of native and naturalized species),
- Common (evident among a high fraction of species studied), and
- Statistically significant (Stevens and Miller, 1983; Jassby et al., 1995; Kimmerer 2002; Dege and Brown 2004; Rosenfield and Baxter 2007; Kimmerer et al., 2009; Mac Nally et al., 2010; Thomson et al., 2010).

<u>This latter attribute deserves emphasis: statistical significance of a correlation means it is very unlikely to occur at random. The number of significant correlations between attributes of fish viability (abundance, spatial distribution, life history and productivity) is among the strongest patterns observed in any ecosystem in the world. Although "correlation is not causation," the overwhelming number, diversity, strength, and persistence of correlations between freshwater flow and species' viability in the San Francisco Estuary is exceptionally compelling evidence that flows are mechanistically related to the viability of public trust resources</u>. It is widely acknowledged that freshwater flow drives, influences, or affects numerous other variables that may impact the viability of fish species (e.g., Dugdale et al., 2007; Sommer et al. 2001, 2004; Kimmerer 2004; Cloern and Jassby 2012). Conversely, no other single physical or biological variable explains the declines (and periodic increases) in as many species of fish and wildlife as freshwater flow. Simply put, there is overwhelming evidence supporting the need for action to set standards regarding the timing, duration, frequency, and magnitude of Delta freshwater inflows and outflows to support restoration of the Delta's public trust resources and there is absolutely no evidence that would support a plan for restoring these fish and wildlife beneficial

uses that did not include significant improvement in flow conditions. If the Board had to select the single stressor it should prioritize based on the scientific evidence concerning the certainty of large-scale benefits for fish and wildlife resources, that stressor would be flow alteration – a stressor that the Board has the authority and obligation to address.

b. Large-scale flow improvements are needed to protect beneficial uses in conjunction with actions to mitigate other stressors; absent mitigation of other stressors, flow restoration would need to exceed the 75% Sacramento River inflow and Delta outflow levels identified in the Board's 2010 Delta flow criteria report.

In addition to the need for flow improvements, it is both necessary and desirable to address other stressors of public trust beneficial uses in this ecosystem in ways that complement improvements in freshwater flow. As stated in our 2010 testimony: "In developing flow criteria we have recommended the *minimum* flows required to restore the viability of public trust species *if all other stressors are appropriately mitigated*." TBI et al. 2010, Exh. 1, p. 15 (Emphasis in original); *see also* TBI et al. 2010, Exhibit 2, p. 14. Absent the assumption that physical habitats, water quality, and food web productivity can and should be restored through a suite of flow and non-flow measures, the flows required to maintain public trust benefits in this species would be larger than we have recommended to the Board. A multi-pronged approach to restoration is required; without it, flows would have to be provided at a level much closer to unimpaired flows, as indicated by studies of the flows required to maintain similar fish and wildlife benefits in other aquatic ecosystems (which are also impacted by a variety of non-flow related stressors). The best available information from other aquatic ecosystems suggests that protection of public trust resources in the San Francisco Bay-Delta will be inadequate if other stressors are not substantially alleviated and more than ~15% of the unimpaired flow is diverted or delayed from its natural flow pattern (e.g. Richter et al, 2011; Dahm, 2010).

c. Flow improvements are critical to addressing other stressors.

The complementary point to the discussion above is that flow measures are a key part of the solution to other stressors. For instance, higher peak flow events in the Delta can help control the spread of invasive species and reduce predation that increases when turbidity is low, and higher river inflows can reverse habitat loss and reduce predation by increasing the extent and duration of inundated floodplains. The implications for flow management in the restoration of critical habitats are particularly well-documented in the case of Central Valley floodplains; see, for example Sommer et al. (2001), Sommer et al. (2002) and Jeffres et al (2008).

d. The Board can and should address other stressors in updating the Bay-Delta Plan.

It is important to also point out that the Board can address other stressors in both the Plan's water quality objectives and the program of implementation. For instance, the Board has previously identified the adoption of objectives for floodplain inundation as a potential amendment to the Plan, and we and other parties have submitted detailed recommendations for flow regimes that are specifically designed to optimize the benefits provided by floodplain habitats (TBI et al, 2010, Ex. 3; see also more recent Phase 2 testimony of American Rivers.). Furthermore, the Board can include actions it can take to address other stressors using different powers than through its water quality objective setting and water right permitting authorities, and include them in the program of implementation. Finally, in the program of implementation the Board can also identify actions that other entities are taking or should take to address other stressors. We plan to provide the Board in the near future with a list of such actions for potential inclusion in the program of implementation.

3. The scientific basis for amending the Bay-Delta Plan to improve flow conditions continues to be extremely strong, despite assertions to the contrary during the workshops

In this section, we briefly review and rebut a number of assertions regarding the scientific basis for adopting new objectives that improve flow conditions. A summary table of assertions and responses is provided in Appendix 1.

a. Flow correlations are statistically significant and biologically important.

Statistically significant, high order correlations between freshwater flow into, through, and/or out of the Delta and the abundance of native and naturalized aquatic species in the Delta are found among an extremely diverse set of organisms, they are persistent over decades of sampling, and apparent in data sets of numerous long term aquatic community sampling programs (e.g., Stevens and Miller 1983; Jassby et al. 1995; Kimmerer 2002; Rosenfield and Baxter 2007; Sommer et al. 2007; Feyrer et al. 2009; Kimmerer et al. 2009; Feyrer et al. 2010). It is highly likely that strong correlations between abundance and flow exist for other organisms that have not been studied or which sampling programs do not measure effectively. Furthermore, statistically significant correlations between one flow attribute (e.g. Delta inflow) and abundance do not justify discounting the existence of similar relationships between other flow attributes (e.g. Delta outflow) and abundance of the same species – for example, the strong relationship between Delta inflow/floodplain inundation and Sacramento splittail abundance (Sommer et al. 2004; Sommer et al. 2007; etc.) does not diminish the potential for a separate (additional) relationship between Delta outflow and Sacramento splittail abundance (e.g. Kimmerer 2002) because flows in these two areas would affect different life stages. Although it is true that "correlation does not equal causation", statistically significant correlations do not generally occur at random (that is the definition of statistical significance) and multiple corresponding, long-term, high-order, significant correlations represent very strong evidence of an (or multiple) underlying mechanistic relationship(s) between freshwater flow and abundance of Public Trust resources.

b. There is no convincing evidence that either abundance estimates or flow correlations are based on misuse of datasets and/or faulty datasets.

We strongly support application of consistent aquatic community sampling methodologies and efforts to correct (where necessary) for unintended trends or changes in employing those methods. However, the suggestion that the strong, persistent, widespread correlations between species' abundance and freshwater flow conditions in the Delta that have been detected by diverse sampling programs (including the Fall Midwater Trawl, Bay Study, and/or Suisun Marsh sampling program) are somehow driven by bias in the sampling program(s) [SJTA 2012a. (p. 2), SJTA 2012b. (p. 62), SVWU 2012 (p. 11-14), SWC 2012 (p. 13-18)] or redistribution of the organisms sampled [SWC 2012 (p. 7-8)] is far-fetched. For example, Rosenfield and Baxter (2007) explicitly studied the value of the Fall Midwater Trawl (FMWT) index as a measure of longfin smelt abundance, comparing it to other survey programs (the Bay Study Midwater Trawl and Suisun Marsh survey) that sample year round and in different areas; their conclusion, based on the apparent spatial and temporal distribution of longfin smelt in the estuary, was that the FMWT was well-suited to provide relative (e.g. year-to-year) measures of longfin smelt abundance and distribution. Rosenfield and Baxter (2007) also created a coarse metric that combined abundance measures from these different sampling programs and that metric (based on simple presence-absence at sampling sites throughout the Bay, Suisun Marsh, and west Delta) showed a significant decline in spawning-age longfin smelt over time that was significantly correlated with flow. Similarly, declines in Delta smelt, Chinook salmon, *Crangon* shrimp and other Delta species have been observed in numerous sampling programs over several decades (IEP, 1999; Baxter et al, 2010; CDFG, 2010a; Mattern et al, 2002). No one claims that any particular current sampling program is ideal for measuring abundance and distribution of all species of pelagic fish; however, the San Francisco Estuary is among the best-studied aquatic ecosystems on Earth – the patterns detected and confirmed by multiple, long-term ecosystem sampling programs in the Delta are real, of major concern, and more than sufficiently robust to justify a rapid and dramatic response by the State Board.

c. Flow is the master variable; there is no evidence that other stressors are more important and/or disconnected from flow alteration

Flow is clearly a dominant variable that controls or moderates other potential stressors on fish populations; most scientists agree that it is the single most important stressor to the ecosystem (e.g., Baxter et al, 2010) because it has such a strong effect on fish populations and various factors that control those populations. There are many different ways for fish to die in the Delta (i.e., there are many different potential "stressors" on their populations), including food limitation, direct entrainment-related mortality, or stress from poor water quality conditions. We do not argue that these "other stressors" may not be important; rather we think that the role of freshwater flows in alleviating or mediating these stressors must be dealt with directly. As described above, our flow recommendations derive from freshwater flows that corresponded to healthier fish populations in the recent past and must be combined with successful efforts to restore productive habitats and water quality in the Delta.

There is simply zero evidence that an "anything but flow" approach will stop the ongoing degradation of the Delta ecosystem, much less reverse that decline, as some have suggested (e.g. SWC, 2012, p. 1, 5, 9-14 [LFS decline not linked to flow, but to introduction of Amur River clam], SJTA 2012b, p. 37-44 [predation is the real problem]). For example, some have argued that ammonium concentrations (or the ratio among nutrients in the Delta's waters) impedes primary production in the Delta (phytoplankton; SWC, 2012, p. 14, 22-23); from this, they have inferred that reduced primary productivity currently impairs production of fish prey items (zooplankton) and further, that the reduction in fish prey limits fish production. Although this argument may sound reasonable, there is actually very little evidence to support this chain of causation on most (if any) fish species of concern; additionally, studies in other ecosystems generally have not detected responses to changes to one level of production (primary, secondary, etc.) in trophic levels more than one level above or below the trophic level that changed. Also, the alleged statistical support for the linkage between ammonium concentrations and fish populations is extremely flawed; Cloern at al. (2012) indicate that the primary publication underpinning this hypothesis is riddled with statistical errors. and they found:

"...no *history for regression (or correlation) analyses on CUSUM-transformed variables prior to its use by Breton et al. (2006), and we have found no theoretical development or justification for the approach. We prove here that the CUSUM transformation, as used by ... Glibert (2010), violates the assumptions underlying regression techniques. As a result, high correlations may appear where none are present in the untransformed data... Regression analysis on CUSUM-transformed variables [the method used by Glibert 2010] is, therefore, not a sound basis for making inferences about the drivers of ecological variability measured in monitoring programs.* [Emphasis added] [p. 665]

Cloern et al (2012) conclude:

"... Glibert (2010) inferred a strong negative association between delta smelt abundance and wastewater ammonium from regression of CUSUM transformed time series. However, the Pearson correlation (r = -0.096) between the time series ... is not significant, even under the naive ... assumptions (p = 0.68). In short, correlations between CUSUM-transformed variables should not be used as a substitute for analysis of the original untransformed variables." [Emphasis added] [p. 668]

Furthermore, the transfer of impairments on primary production to secondary and fish productivity is not supported by analysis of fish abundance data (except, possibly, in the case of longfin smelt; Kimmerer 2002), nor can it explain why those species that live closest to the putative source of ammonium have flourished (e.g., American shad; on a flow corrected-basis) since the late 1980s, while no change has been observed in the flow-abundance correlations (or lack thereof) for Delta resident species (e.g. Sacramento splittail and Delta smelt), as would be predicted by a nutrient-primary-secondary production mechanism. What is acknowledged by all parties is that improved freshwater flows can flush exess ammonium out of the Delta that may concentrate there as a result of severely reduced freshwater flow pulses. Increased flows would tend to moderate negative effects caused by high concentrations (e.g. Dugdale et al, 2007). If the main cause of high ammonium concentrations is not directly related to human activities (some expect that excess ammonium is produced by high densities of the invasive clam, *Corbula amurensis*, which would not be directly controllable), then increased freshwater flows may be the only way to mitigate an effect of ammonium pollution, at least in the short-term.

Predation has also been offered as a source of problems for native Delta species (SJTA, 2012a, p. 15; SJTA., 2012b, p. 37-44; SWC 2012, p. 23-24); this despite the fact that one of the major flow-dependent predator species in this ecosystem, striped bass, has also declined significantly (e.g., Kimmerer 2002). Another suite of predators has taken root in the Delta over recent decades and these shallow water predators benefit from introduction of aquatic weeds such as *Egeria*. One thing the new invasive predators (Centrarchid bass/sunfish and Mississippi silversides) and the submerged aquatic vegetation share in common is a preference for shallow habitats with slow moving currents. Thus, flow modifications in the Delta have favored the invasive predators (and the SAV from which they also benefit) by creating ecological conditions that resemble those of lakes in the southeastern United States and South America. These invaders will not thrive (or will at least be put at a disadvantage) if flow patterns in the Delta are restored to more naturalpatterns of seasonal and interannual variability. In the meantime, focusing on reducing predation by direct predator removal or targeted engineering to eliminate predator "hotspots" will likely be exceptionally expensive and ineffective here as it has proved to be in other regions of the country, such as the Columbia-Snake River ecosystem. Again, increased flow rates into, through, and out of the Delta are expected to reduce this "other stressor" on native fishes by (1) reducing exposure to high predator populations, (2) reducing predator efficiency, and (3) (occasionally) increasing turbidity – evidence of such an effect is apparent in CDFG's San Joaquin salmon survival model (2010a) and Bowen (2010).

d. There is convincing evidence that entrainment has population level effects and that Old and Middle River criteria or other measures to limit entrainment and reverse flows is justified and appropriate.

Since the Board issued its 2010 flow criteria report (SWRCB 2010), evidence that entrainment-related mortality is periodically an important stressor on certain fish populations has increased, as has evidence that south-Delta exports alter ecosystem food web productivity. Kimmerer (2011) reaffirmed the findings of his 2008 paper, which found that, in some years, a large fraction of the total Delta smelt population and Chinook salmon juvenile year-class may be entrained at the export facilities. In addition, Kimmerer (2011) demonstrated that because of the nature of the salvage impact and population index data, significant levels of entrainment could drive a population towards extinction while remaining undetected by common statistical techniques**.** In addition, Rosenfield (2010) documented a strong correlation between spring

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Delta freshwater outflows and entrainment of longfin smelt juveniles; entrainment was inversely proportional to the previous FMWT index, thus the effect of entrainment is disproportionately high when the longfin smelt population is low. While USFWS (2012) concluded (without analysis) that longfin smelt entrainment was not a continual problem for this population, it also suggested that entrainment rates in certain years could have had a significant impact on the population – thus, entrainment may have an episodic negative impact on the critically imperiled longfin smelt population. Furthermore, Maunder and Deriso (2010) found a strong effect of entrainment of adult Delta smelt on population dynamics in this imperiled species, though they inexplicably removed that variable from their conclusion because the strength of the effect was "too strong". Despite restrictions on Old and Middle River reverse flows implemented as part of the Biological Opinions' RPAs, there have been record or near-record entrainment events for Sacramento splittail, sturgeon, Sacramento sucker, longfin smelt and other fishes in recent years (TBI, 2011); this result suggests that OMR flow criteria contained in the RPAs are not adequate to protect other species in the Delta.

Some argue that it is a good sign when fish salvage rates are high (because it suggests that fish populations are high), but also argue that low salvage years prove that high exports and reverse flows are not a problem (e.g. SWC, 2012, p. 25-27: reverse flows and entrainment do not equate to population effects per Maunder and Deriso). While the exact scope of the salvage problem remains to be completely described, a few things are certain (see TBI, 2011):

(i) most fish salvaged at the South Delta export facilities (and the much larger amount of fish food, eggs, and larvae that are exported without enumeration) are lost to the ecosystem .
(ii) salvage numbers vastly underestimate the impact of entrainment as pre-screen mortality (within the export facility canals) is one or more orders of magnitude greater than salvage.
(iii) entrainment-related loss is indiscriminant and continuous.
(iv) fish and food web resources can be protected by imposing restrictions on exports in the form of minimum OMR flows, export:inflow ratios, and bypass flows (i.e. Delta outflows).

4. The concept of "regime shift" is neither consistent with scientific understanding of ecosystem dynamics nor an appropriate basis for determining that a healthy native ecosystem cannot be restored.

Despite the diversity and magnitude of changes that have been wrought on the Bay-Delta ecosystem, there is every reason to believe that restoration of freshwater flows will contribute to improved viability and persistence of fish and wildlife beneficial uses and public trust resources. When flow improvements are combined with proposed habitat and water quality restoration actions (a strategy we have helped develop and have consistently advocated for), there is a strong scientific basis for the expectation that these beneficial use and resources in the Bay-Delta estuary can be restored to levels that are sufficient and sustainable – there is even reason to hope that some resources can be restored to levels that exceed those seen during the onset of the modern period of community sampling (e.g. the late 1960s). The argument that there has been a "regime change" and so it is not possible to "go back" to an ecosystem that supports thriving fish and wildlife populations is deceptive and fundamentally unscientific. The "regimes" (current and past) referred to by this line of reasoning are completely undefined and there is no way to test scientifically whether it is possible to revert to a previous regime or what would be required to do so. The notion of static "regimes" where the abundance and distribution of fish and wildlife populations remain relatively stable in a climax state harkens back to the discredited arguments of community ecologists from the early 1900s (e.g. Clements 1936). In the decades since these ideas held sway, ecologists have learned that ecosystems are in a near constant state of change where productivity is governed largely by temperature, elevation, and latitude while diversity is regulated by productivity, barriers to immigration, and the disturbance (physical variability) regime. In the San Francisco Bay-Delta, humans have clearly changed the rates of species immigration, and global climate change will likely further alter system energetics. However, by restoring freshwater flow rates, as well as the seasonal and inter-annual variability of that flow to levels seen in the not-too-distant past *and* restoring habitats that have been unavailable for >50 years, we can expect to counter the decline of native fish and wildlife species and may (in certain cases) establish populations that are more abundant, diverse, and widespread than those we have measured since sampling began in the late 1960's.

5. There is no scientific basis for implementing actions to restore physical habitat as a substitute for improving flow conditions.

For many years we have been involved in helping advocate for, design, and implement programs and projects to create, restore and expand the extent of a diversity of physical aquatic habitats when there is a relatively high degree of certainty that such projects will primarily benefit native species, either directly (e.g. as spawning or rearing habitat) or indirectly (e.g. via exports of food to native species' habitats). However, as discussed in our workshop 1 submission (pp. 19-22), it is far from certain that all of the aquatic habitat restoration projects proposed by various parties will benefit desirable native species more than they will benefit invasive predator and competitor species. For example, during a preliminary, incomplete review of habitat restoration projects considered under the Bay Delta Conservation Plan (DRERIP, 2009), many of the shallow habitat restoration projects (particularly those in the eastern, central and southern Delta) scored low on the magnitude of potential benefits and the likelihood that those benefits would be achieved. On the contrary, experts engaged in the review felt that many of these projects could pose a risk to native species if they became habitat for invasive predators, competitors, or submerged aquatic vegetation. Similarly, the National Research Council was dubious of plans to restore food supplies for Delta smelt by restoring wetlands (NRC, 2010). While restoring historical habitats continues to be an attractive and worthwhile endeavor, expected changes in the regional climate (e.g. warming) and the introduction of non-native species may prevent certain in-Delta restored habitats from performing their historic function, especially if freshwater flows remain drastically reduced by diversions and exports.

Furthermore, it is not at all clear that all the feasible restoration projects taken together will produce and export sufficient volumes of prey to pelagic habitats where many of the key public trust resources live. Use of large scale habitat restorations to supplement the Bay-Delta food web is a compelling idea, and one that should be refined and improved (e.g. through a series of pilot projects); but there are no guarantees that restored habitats will function like historical habitats (see above) or that the area that could be potentially restored will be sufficient (especially without restored freshwater flows) to make a dent in the productivity gap in this ecosystem. Even with adequate flows, achieving the necessary food web subsidy believed to be required to support viable populations of public trust-related fish species will probably only be successful if restoration occurs on a massive scale (e.g. tens to hundreds of thousands of acres) – under any scenario, restoration of this magnitude will take decades to achieve.

The inescapable fact is that in the complex and changing environment of the Bay-Delta, ensuring adequate flow conditions is the action with the highest degree of scientific justification, certainty of successful result, and magnitude of benefit. It is not likely to be sufficient in and of itself to solve every problem plaguing this system. But every other action is likely to be ineffective absent the critical element of flow restoration.

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