Physical Public Benefits Tab

Attachment 2: Ecosystem Documentation Priorities 1, 2, 10, 14, 15, and 16

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Table of Contents

Tables

Figures

Acronyms and Abbreviations

°F	Fahrenheit
CDFW	California Department of Fish and Wildlife
cfs	cubic feet per second
CV	Central Valley
CVP	Central Valley Project
DCH	Designated Critical Habitat
EFH	Essential Fish Habitat
GCID	Glenn Colusa Irrigation District
IEP	Interagency Ecological Program
MSA	Magnuson-Stevens Fishery Conservation and Management Act
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NWR	National Wildlife Refuge
PCE	primary constituent elements
PFMC	Pacific Fishery Management Council
RECTEMP	U.S. Bureau of Reclamation Temperature Model
RM	River Mile
SWRCB	State Water Resources Control Board
TCCA	Tehama-Colusa Canal Authority
USRWQM	Upper Sacramento River Water Quality Model

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Ecosystem Priority 1: Provide cold water at times and locations to increase the survival of salmonid eggs and fry

Improved Temperatures

Cold water benefits will be realized by operating Sites Reservoir and Shasta Lake in cooperation to preserve a greater volume of coldwater pool storage in Shasta Lake. This will be accomplished by substituting water from Sites Reservoir to meet a portion of the CVP water demand from Shasta (especially in the lower GCID and TCCA service areas) thus allowing cold water to be conserved in storage in Shasta Reservoir to benefit anadromous fish. This water will be released to maintain appropriate water temperatures in the Sacramento River, with particular emphasis on the months of highest potential water temperature related impacts. The area of temperature improvement for the Sacramento River resulting from the Project is shown in Figure A2-1 below and temperature improvements in Critical water years are shown in Table A2-1. Shasta Lake average end-of-month storage in May under simulated current, 2030, and 2070 dry water year conditions increases by 90 thousand acre feet (TAF) to 100 TAF above the respective without-project conditions.

Table A2-1. Temperature (°F) Improvements in Critical Water Years (July through September Period)

Sacramento River Location	Current Condition without Project (°F)	Current Condition with Project (°F)	Difference (°F)	WSIP 2030 without Project (°F)	WSIP 2030 with Project (°F)	Difference (°F)
Bonnyview	56.5	55.1	-1.4	56.5	55.9	-0.6
Balls Ferry	58.0	56.6	-1.4	58.1	57.5	-0.6
Jellys Ferry	59.2	57.9	-1.3	59.4	58.8	-0.6
Bend Bridge	60.1	58.9	-1.2	60.3	59.7	-0.6

Through releases from Sites Reservoir to meet TCCA and GCID irrigation diversions and equivalent reductions in CVP Shasta Lake releases, demands on Shasta Lake storage could be reduced and the coldwater pool maintained for a longer time at higher levels than are currently achievable. Shasta Lake release patterns could be shifted in season and between adjacent years to improve coldwater storage and flow management for salmon and other species using the portion of the Sacramento River between Keswick Dam and the Red Bluff Pumping Plant as habitat. Similar increases in storage can be achieved in Lake Oroville (average end-of-May increases of 25 to 35 TAF).

The operation of Sites Reservoir also provides opportunity for improved temperature conditions in the American River. Results for the American River at Watt Avenue are provided in Table A2-2 and the area of temperature improvement for the American River is shown in Figure A2-2.

Table A2-2. American River Temperature (°F) Improvement at Watt Avenue (July to September)

Year Type	2015 without Project	2015 with Project	Difference	WSIP 2030 without Project	WSIP 2030 with Project	Difference
Average	66.7	65.8	-0.9	70.6	69.9	-0.6
Dry	68.0	67.2	-0.8	70.7	70.5	-0.2
Critical	71.6	70.2	-1.4	73.6	73.1	-0.5

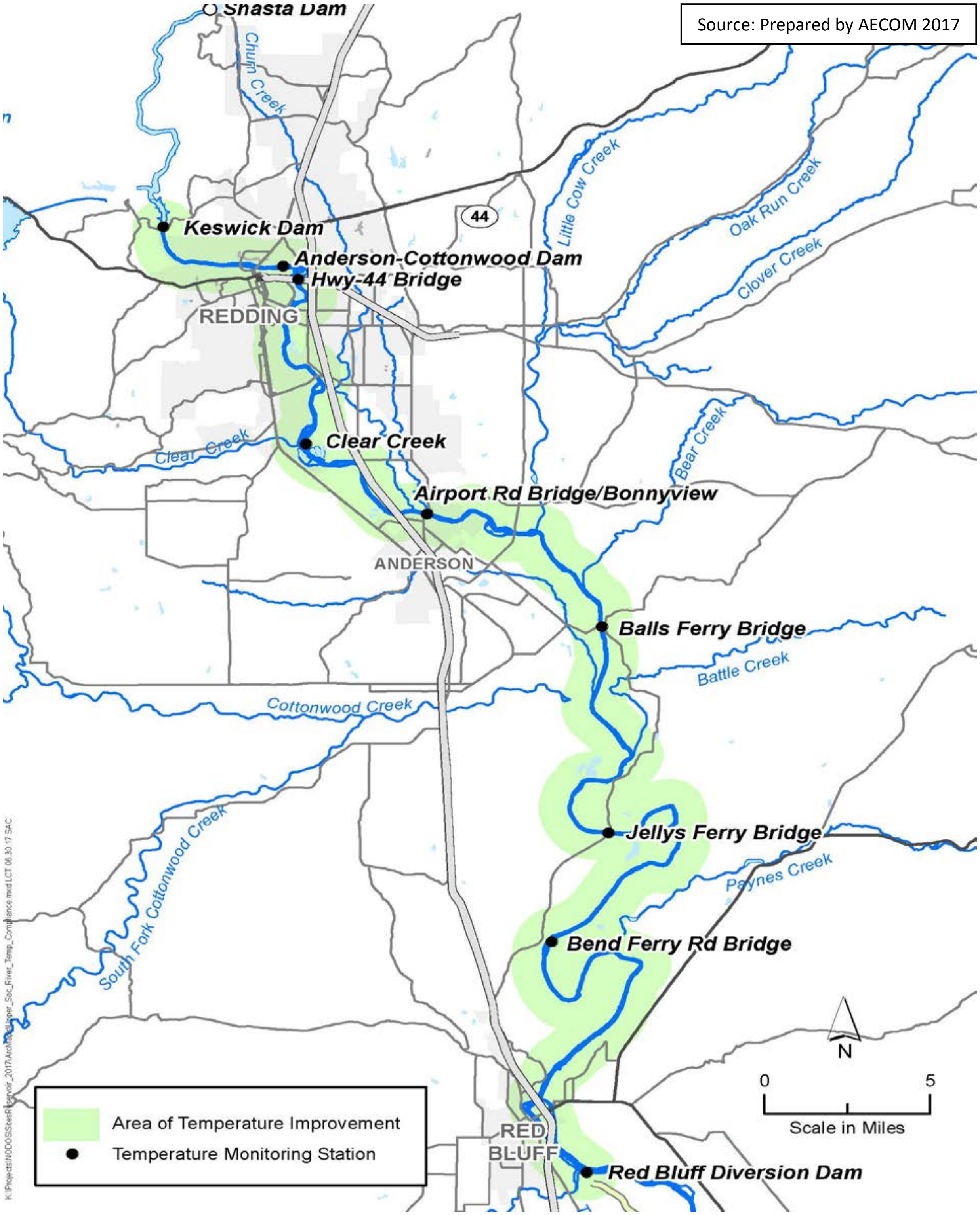


Figure A2-1: Area of Temperature Improvement for the Sacramento River

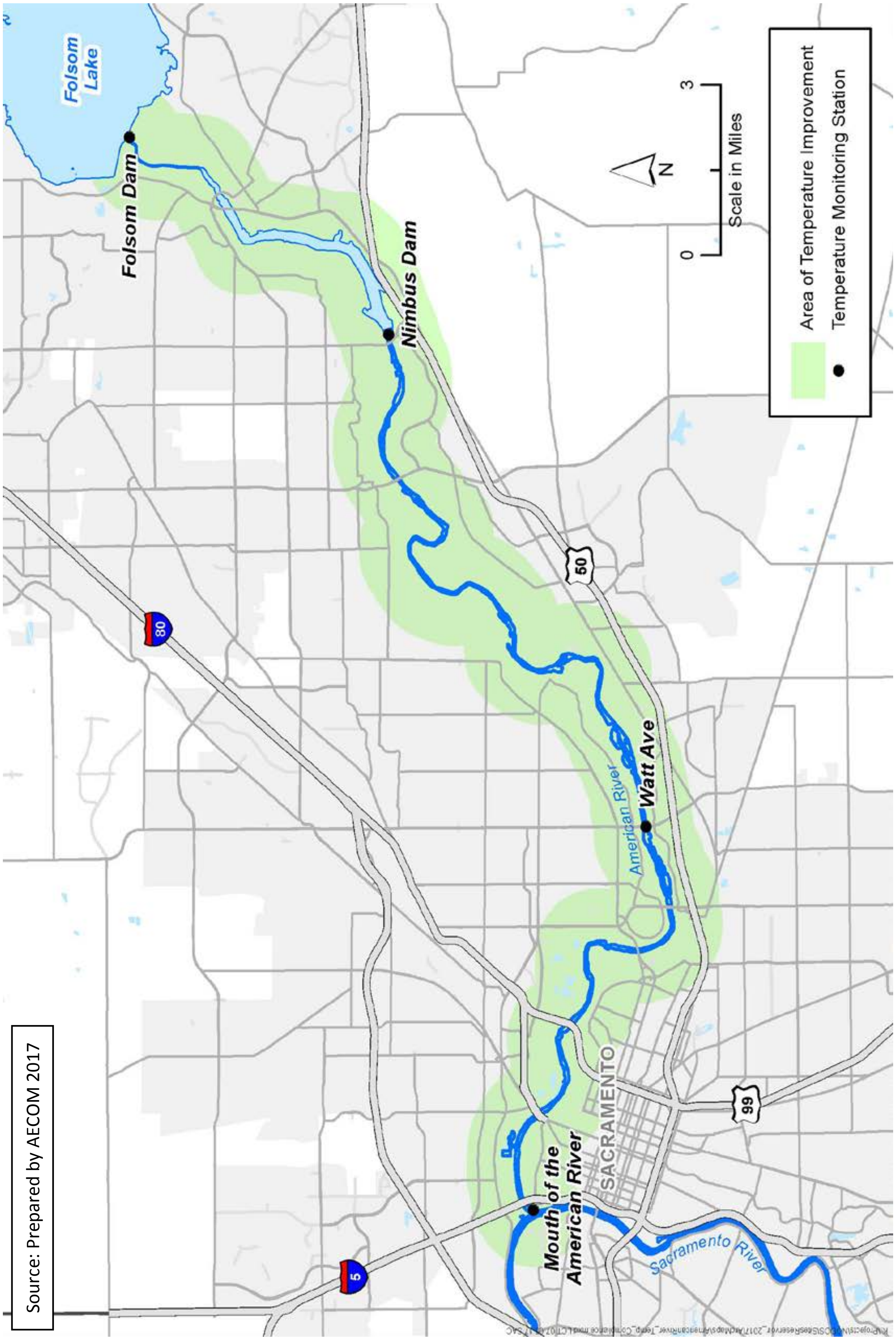


Figure A2-2: Area of Temperature Improvement for the American River

Reduction in Sacramento River Winter-run Chinook Salmon Mortality

The estimated percent reduction in mortality to Winter-run Chinook salmon eggs and fry due to thermal benefits of the project are summarized in Table A2-3, separated by location and water year type.

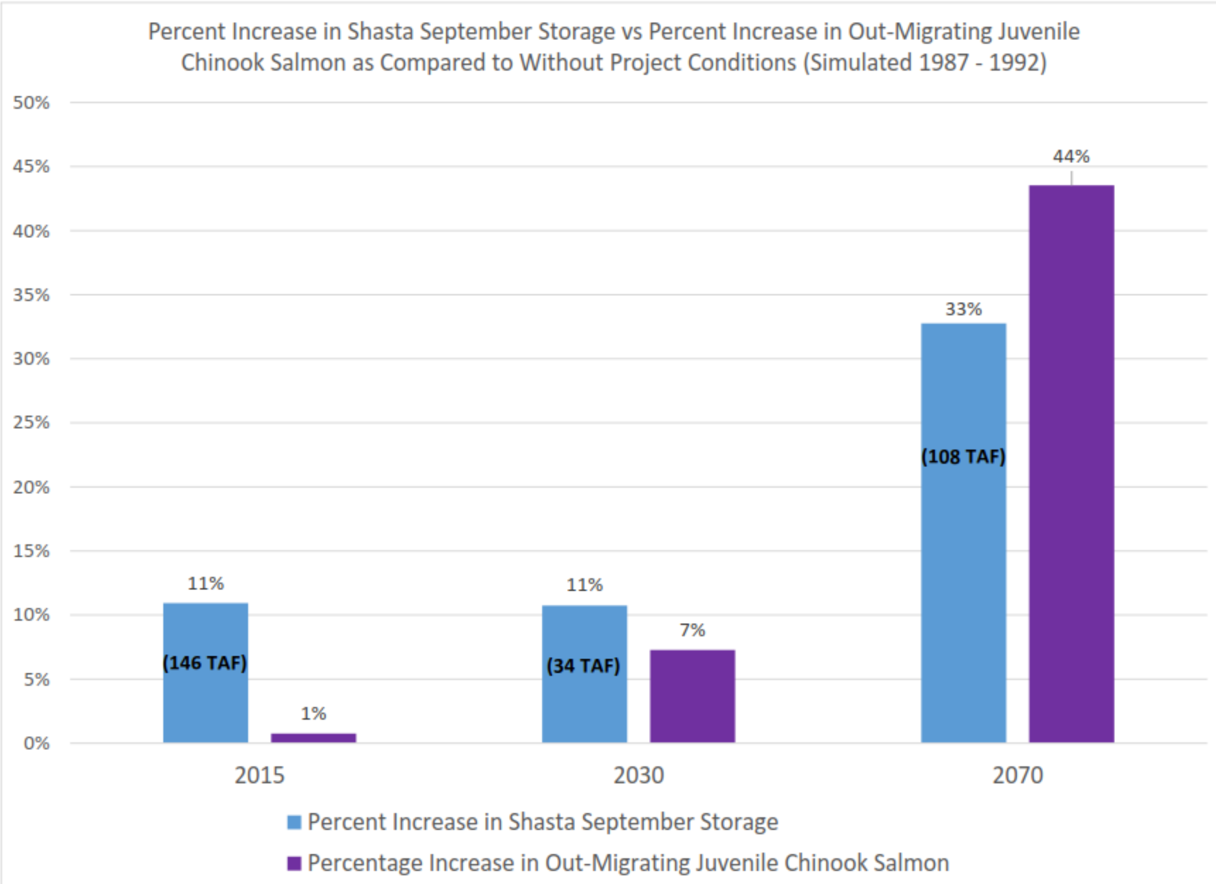
Table A2-3. Estimated Percent Reduction in Mortality Due to Thermal Benefits of Project to Salmonid Eggs and Fry

Winter-run Chinook							
Locations along the Sacramento River	**Keswick**	**Bonnyview Bridge**	**Balls Ferry**	**Jellys Ferry**	**Bend Bridge**	**Red Bluff**	**Below Red Bluff**
Eggs							
Dry Water Years							
August	-	-	-	-	-	-	-
September	-	-	**8%**	-	-	-	-
October	-	-	-	-	-	-	-
Critical Water Years (15% of total water years)							
August	-	-	**15%**	-	-	-	-
September	**8%**	**7%**	**25%**	-	-	-	-
October	-	-	-	-	-	-	-
Fry (Alevins)							
Dry Water Years							
August	-	-	-	-	-	-	-
September	-	-	**25%**	-	-	-	-
October	-	-	-	-	-	-	-
Critical Water Years (15% of total water years)							
August	-	-	-	-	-	-	-
September	-	-	**15%**	-	-	-	-
October	-	-	-	-	-	-	-

Beginning at Keswick Dam and continuing in a downstream direction the results were:

Sacramento River Below Keswick Dam (RM 302.0) (Table SQ2-1a)

Critical water years only (15% of total water years): During September 2030 without the project the mean monthly water temperature is projected to be 57°F, thus exceeding the upper water temperature optimum of 56°F for egg incubation, but less than the upper water temperature of 58°F for pre-emergent alevins. At this temperature it is expected that egg mortality will increase by 8 percent after 24 days of exposure. No increase in mortality for pre-emergent alevins will occur (Vogel 2015, Table 3, page 10). With the project in place 56°F will not be exceeded in September, and egg and alevin mortality will not increase over natural levels. Therefore, the project would reduce egg mortality during September by approximately 8 percent for those eggs remaining in redds. In October 2030 both with and without the project the mean monthly water temperature will rise to 58°F, thereby increasing egg mortality by 15 percent over 22 days of exposure for any remaining incubating eggs. The number of incubating eggs in October is expected to be small. There would be no increase in alevin mortality with or without the project (Vogel 2015, Table 3, page 10). Both operating scenarios would have similar results by increasing egg mortality during October. During November only pre-emergent fry remain in the spawning gravels and water temperatures with and without the project remain less than 58°F, indicating no increase in mortality with or without the project over natural levels.



*Values presented in TAF represent increases in Shasta September Storage as Compared to Without Project Conditions

Sacramento River at Bonnyview Bridge, Redding (RM 291.8) (Table SQ3-1a)

Note that most Winter-run spawning occurs (greater than 90 percent) upstream of this location which is 10.2 miles downstream of Keswick Dam.

Critical water years only (15% of total water years): During September 2030 the mean monthly water temperature without the project is projected to be 58°F, thus exceeding the upper water temperature optimum of 56°F for egg incubation, but not exceeding the thermal optimum of 58°F for pre-emergent alevins. The 58°F water temperature would result in an estimated 15 percent increase in egg mortality over a 22 day period for those eggs still incubating. With the project in place, egg mortality would decline to 8 percent over a 24-day exposure period (Vogel 2015, Table 3, page 10). Thus, the project would reduce egg mortality during September by approximately 7 percent. Pre-emergent alevins would not be exposed to greater mortality than natural levels with or without the project during September. During October 2030 egg mortality without the project is projected to be 59°F, thus exceeding the upper water temperature optimum of 56°F for egg incubation. This temperature would result in an estimated 25 percent increase in mortality over natural levels if exposed for 20 days for those eggs remaining. The number of incubating eggs in October is expected to be small. During October 2030 with the project the mean monthly water temperature is projected to be 58°F which would result in a 15 percent increase in egg mortality over natural levels if exposed for 22 days for those eggs remaining. Therefore, the project would reduce egg mortality by 10 percent at this location during October. Without the project pre-emergent alevins would be exposed to a 10 percent higher mortality rate if exposed for 14 days. With the project, no increase in mortality would occur. Therefore, the project would reduce pre-emergent alevin mortality by 10 percent over the without project scenario. During November only pre-emergent fry remain in the spawning gravels and water temperatures with and without the project remain less than 58°F, indicating no increase in mortality with or without the project.

Sacramento River at Balls Ferry (RM 276.0) (Table SQ4-1a)

Note that all Winter-run spawning occurs 13 miles or further upstream of this location. Balls Ferry is 26 miles downstream of Keswick Dam. No redds with incubation eggs and pre-emergent alevins would be located at Balls Ferry. Balls Ferry is a water temperature compliance point with a target water mean daily water temperature of 56°F (State Water Resources Control Board WR 90-5 [1990]).

Dry water years only (22% of total water years): During September of 2030 mean monthly water temperature is projected to reach 57°F, thus exceeding the upper water temperature optimum of 56°F for egg incubation, but not exceeding the thermal optimum of 58°F for pre-emergent alevins. At this temperature it is expected that egg mortality would increase by 8 percent after 24 days of exposure, if eggs were actually present at this location. No increase in mortality for pre-emergent alevins would occur if alevins were actually present (Vogel 2015, Table 3, page 10). With the project in place 56°F would not be exceeded in September, and egg and alevin mortality would not increase over natural levels were eggs and alevins actually present at this location. Therefore, the project would reduce egg mortality during September by approximately 8 percent for those eggs remaining in redds if eggs were actually present at Balls Ferry. In October 2030 the opposite is true, with the project resulting in a mean monthly water temperature of 57°F and without the project a projected 56°F. Therefore, the theoretical increase in egg mortality would be 8 percent with the project and no increase without the project. No impact to pre-emergent alevins would occur with and without the project if alevins were actually present at this location.

Critical water years only (15% of total water years): The mean monthly water temperature index of 56°F for egg incubation is exceeded from July through October 2030 both with and without the project. In July the mean monthly water temperature with and without the project is 57°F which would result in an 8 percent increase in mortality over natural levels if exposed for 24 days (Vogel 2015, Table 3, page 10). In August this value would increase to 58°F without the project, but remain at 57°F with the project. Therefore, in August, the project would reduce egg mortality by 15 percent if exposed for 22 days. During September the mean monthly water temperature would increase to 60°F without the project and 59°F with the project. Thus, egg mortality would increase by 50 percent without the project over a 12-day exposure and 25 percent with the project over a 20 day exposure. Therefore the project would reduce egg mortality by 25% in September. During October the mean monthly water temperature both with and without the project is 59°F, resulting in an increase in egg mortality of 25 percent for a 20 day exposure for those few eggs still incubating. Pre-emergent alevins would not be exposed to increased mortality until September 2030. During September the mean monthly water temperature is projected to reach 60°F without the project and 59°F with the project. The respective increases in alevin mortality greater than natural levels are 25 percent over a 14-day exposure period and 10 percent over the same period (Vogel 2015, Table 3, page 10). Therefore the project would reduce alevin mortality by 15% in September. During October 2030, the mean monthly water temperature is 59°F with and without the project resulting in a 10 percent increase in mortality over a 14-day period for remaining alevins had they actually been present at Balls Ferry. Alevin mortality would not increase above natural levels during November 2030 for any fish remaining in redds.

In summary, in the reach of the Sacramento River used by spawning Winter-run Chinook salmon from Keswick Dam to Clear Creek, the proposed project in 2030 will reduce the percentage of egg mortality in September and October of critically dry water years from 7 to 10 percent depending on location. In the spawning reach pre-emergent fry (alevins) would not be impacted adversely by water temperature with or without the project.

Species Conservation Plans

The ecosystem improvement is consistent with two recovery actions of National Oceanic and Atmospheric Administration (NOAA) Fisheries Recovery Plan for Winter-run Chinook salmon, Spring-run Chinook salmon, and Central Valley steelhead in the mainstem Sacramento River (National Marine Fisheries Service [NMFS] 2014). The actions in the NOAA Fisheries that will be met are: (1) to develop and apply alternative diversion technologies that reduce entrainment, and (2) evaluate and reduce stranding of juvenile chinook salmon in the channels from Keswick Dam to Colusa, due to flow reductions from Keswick Reservoir, by increasing or stabilizing releases from the reservoir. The ecosystem improvement is also consistent with three of the proposed actions listed in the Sacramento Valley Salmon Resiliency Strategy. These actions are: (1) increase productivity by improving spawning and incubation conditions (habitat and water quality); (2) increase productivity by increasing juvenile salmonid survival; and (3) support the full range of juvenile and adult migration conditions to maintain life history diversity. The project will meet these actions by providing increased flows and management of intake diversions to benefit salmonids in the Sacramento River below Keswick Dam. With improved flows, the project will also enhance and improve the quality of Essential Fish Habitat (EFH) and Designated Critical Habitat (DCH). Essential Fish Habitat is defined in the Magnuson-Stevens Act (MSA) as the waters and substrate necessary for fish spawning, breeding, feeding, or growth until maturity (MSA § 3(10)). The project will improve EFH for Pacific Coast Salmon (all four runs of Chinook included) by providing enhanced thermal refugia, floodplain habitats, and spawning habitat which included in the habitat areas of particular concern for Pacific Coast Salmon (Pacific Fishery Management Council [PFMC] and NMFS 2014). The US Fish and Wildlife Service defines DCH by considering those physical or biological features that are essential to the conservation of a given species, and designating specific areas within the geographic area occupied by the species at the time of listing. The project will provide enhanced DCH's primary constituent elements (PCE) as defined in 70 FR 52488 for steelhead. These PCEs are as follow: more suitable flow conditions, additional rearing sites, and increase in downstream passage.

Ecosystem Priority 2: Provide flows to improve habitat conditions for in-river rearing and downstream migration of juvenile salmonids

The additional water stored in Shasta Reservoir will be released to augment Sacramento River flows downstream from Keswick Dam. These flows will simulate punctuated high flow events that would trigger increased activity in downstream movement of juvenile Chinook Salmon. The greatest value in providing increase in flows in the Sacramento River below Keswick Dam is to emigrating juvenile Winter-run, Fall-run, and Late fall-run Chinook salmon. Similarly, increased water stored from Lake Oroville and Folsom Lake will also be released to benefit habitat conditions for in-river rearing and downstream emigration of juvenile Chinook salmon in the Feather and American rivers.

Sites Reservoir would provide a 4.2% (338 cubic feet per second [cfs]) long term average increase in flows in the Sacramento River between Keswick Dam and the Red Bluff Diversion Dam (Table A2-4). Model results using different water year types show that there is a 7.0% (380 cfs) increase in flows in below normal water years and a 7.6% (334 cfs) increase in flows in dry water years. In 2030, there is a 2.5% (209 cfs) long term average increase in flows, a 3.4% (169 cfs) increase in below normal water years, and a 10.8% (495 cfs) increase in dry water year flows.

Table A2-4. Stabilize Sacramento River Fall Flows

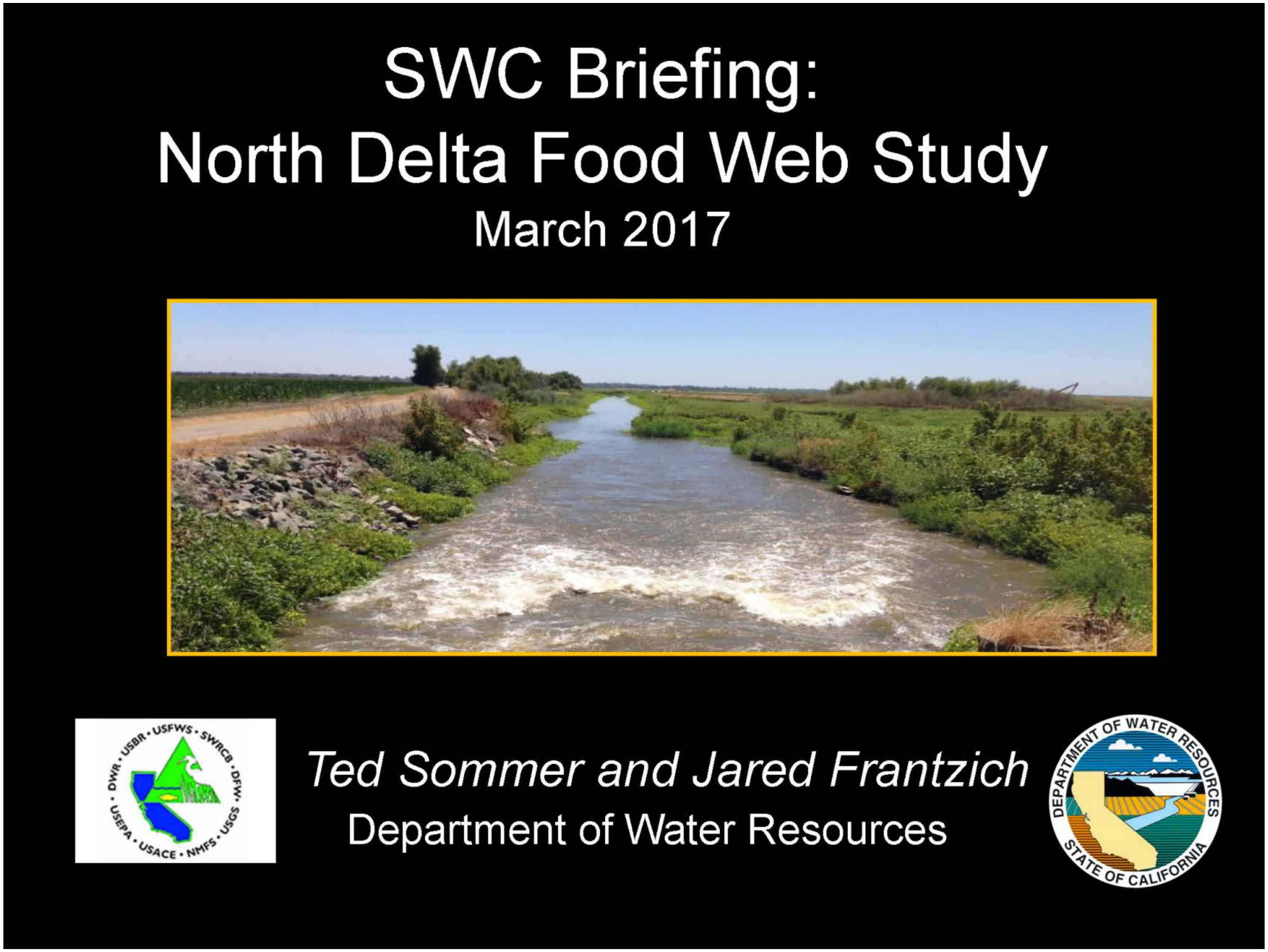
Flow Increase (Nov-Feb)	Current Condition Increase (cfs)	Current Condition Increase (%)	2030 Increase (cfs)	2030 Increase (%)	2070 Increase (cfs)	2070 Increase (%)
Long Term Avg	338	4.2	209	2.5	93	1.1
Below Normal	380	7.0	169	3.4	127	2.2
Dry	334	7.6	495	10.8	163	3.8

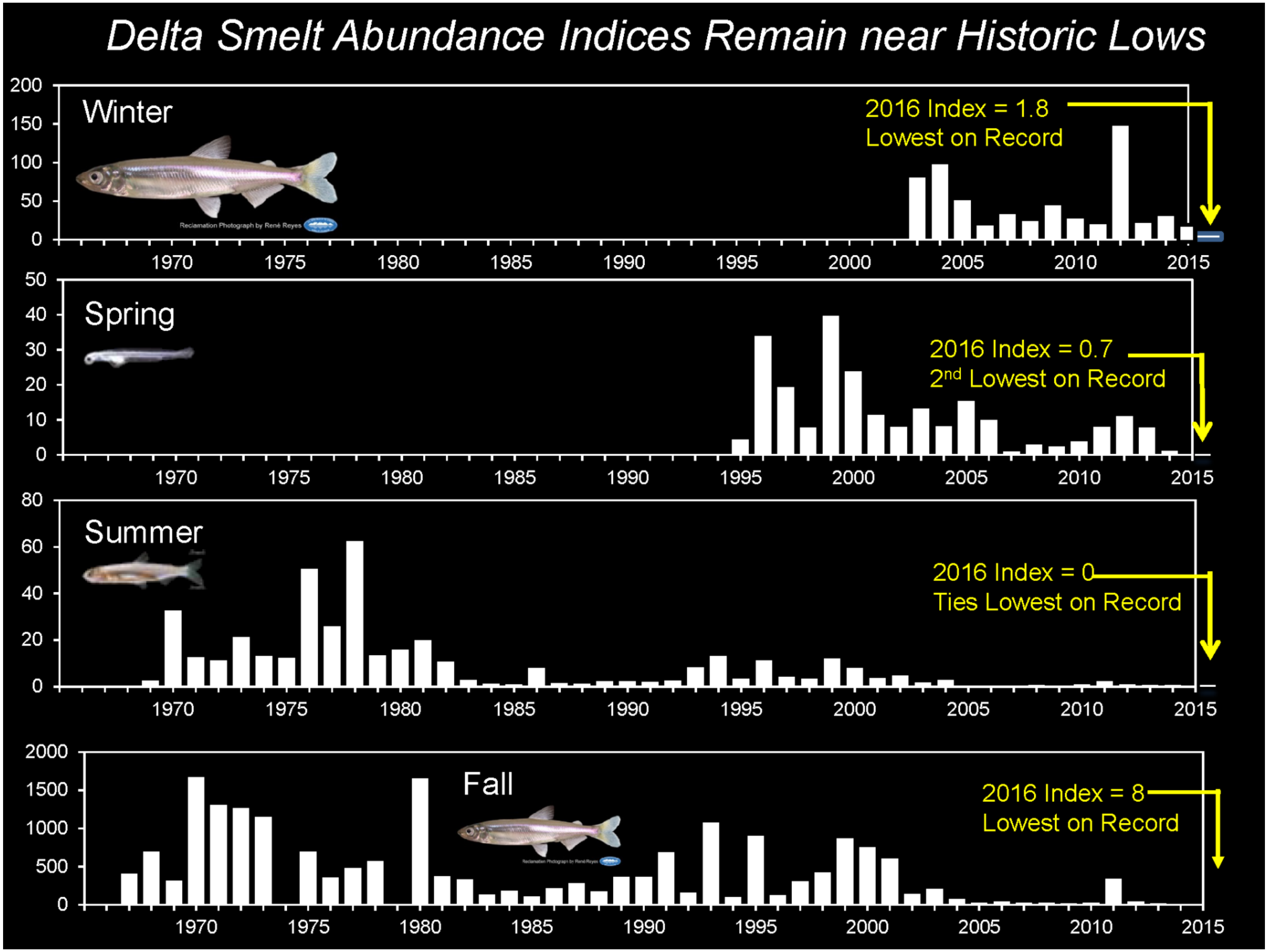
Flow augmentation in the Sacramento River was estimated using the WSIP and provided CALSIM model that showed benefits to fall-run and late fall-run Chinook salmon productions (Table A2-5).

Table A2-5. Increased Juvenile Production Compared to Without Project (SALMOD 2030)

Year Type	Fall-run	Late fall-run
Long Term Avg	435,000	70,188
Wet	28,401	37,827
Above Normal	1,338,057	61,484
Below Normal	118,225	37,207
Dry	19,886	57,277
Critical	1,493,425	208,800

Ecosystem Priority 10: North Delta Food Web Study

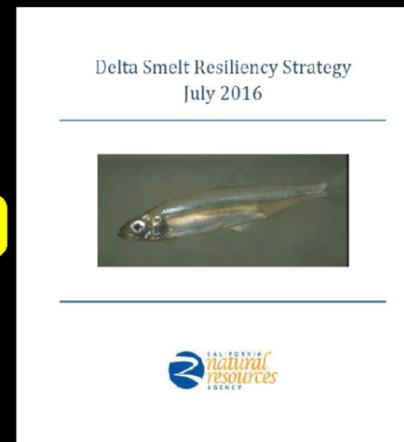




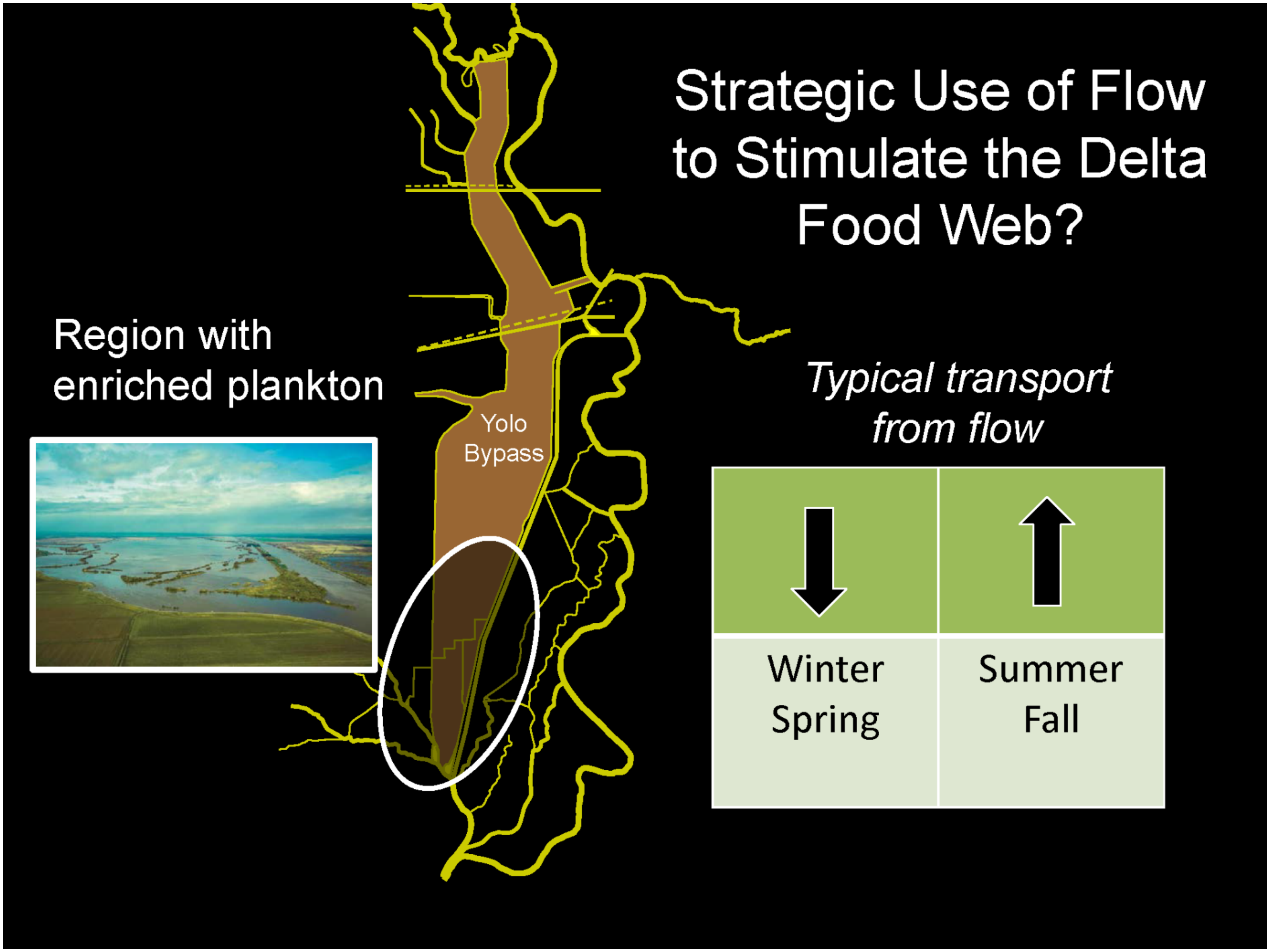
Delta Smelt Abundance Indices Remain near Historic Lows
Winter
2016 Index = 1.8
Lowest on Record
Spring
2016 Index = 0.7
2nd Lowest on Record
Summer
2016 Index = 0
Ties Lowest on Record
Fall
2016 Index = 8
Lowest on Record

Delta Smelt Resilience Strategy

13 Proposed Actions


Delta Smelt Resiliency Strategy
July 2016

- Aquatic Weed Control
- North Delta Food Web Adaptive Management Projects
- Outflow Augmentation
- Reoperation of the Suisun Marsh Salinity Control Gates
- Sediment Supplementation in the Low Salinity Zone
- Spawning Habitat Augmentation
- Roaring River Distribution System Food Production
- Coordinate Managed Wetland Flood and Drain Operations in Suisun Marsh
- Adjust Fish Salvage Operations during Summer and Fall
- Storm water Discharge Management
- Rio Vista Research Station and Fish Technology Center
- Near-term Delta Smelt Habitat Restoration
- Franks Tract Restoration Feasibility Study



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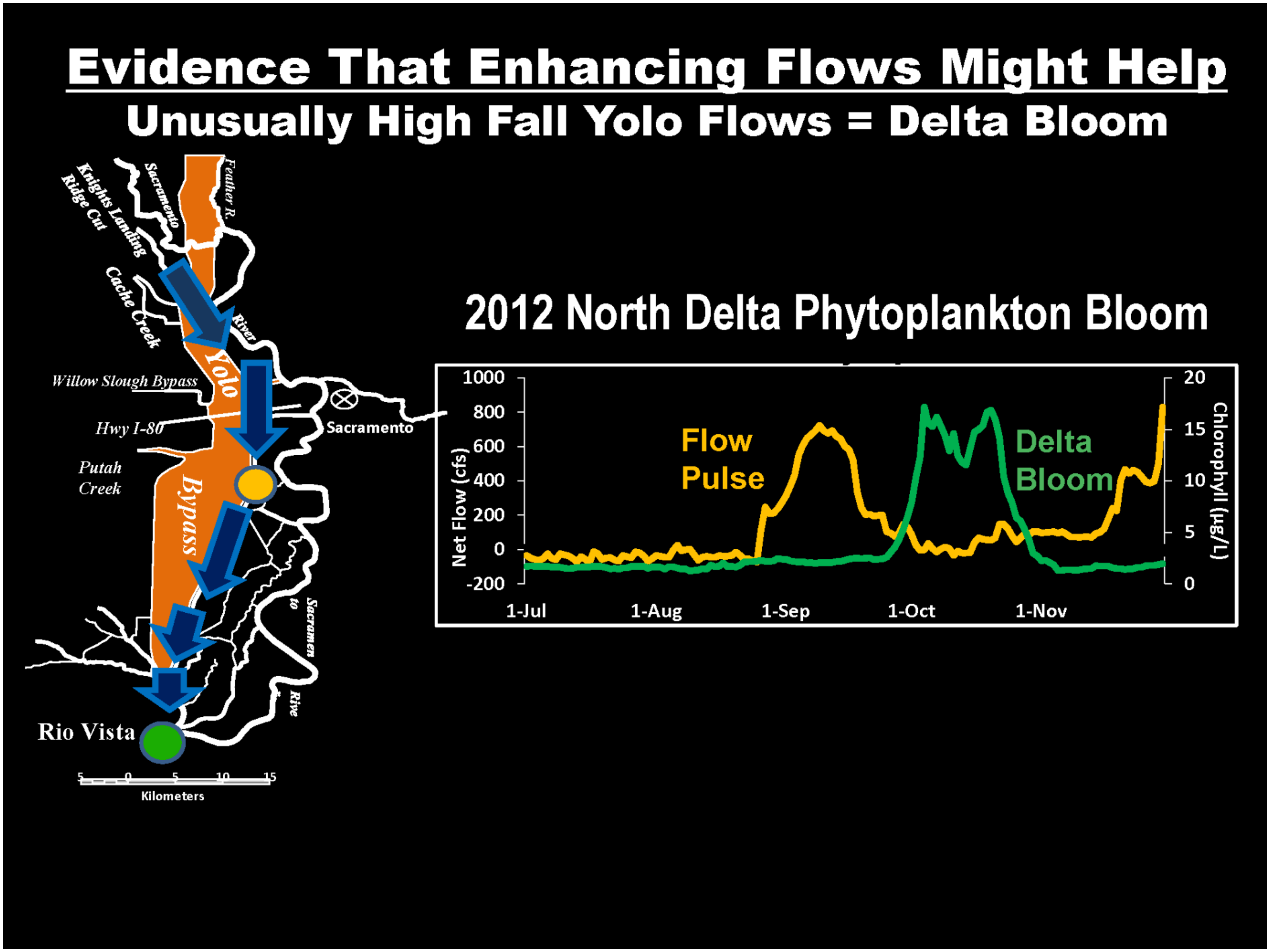
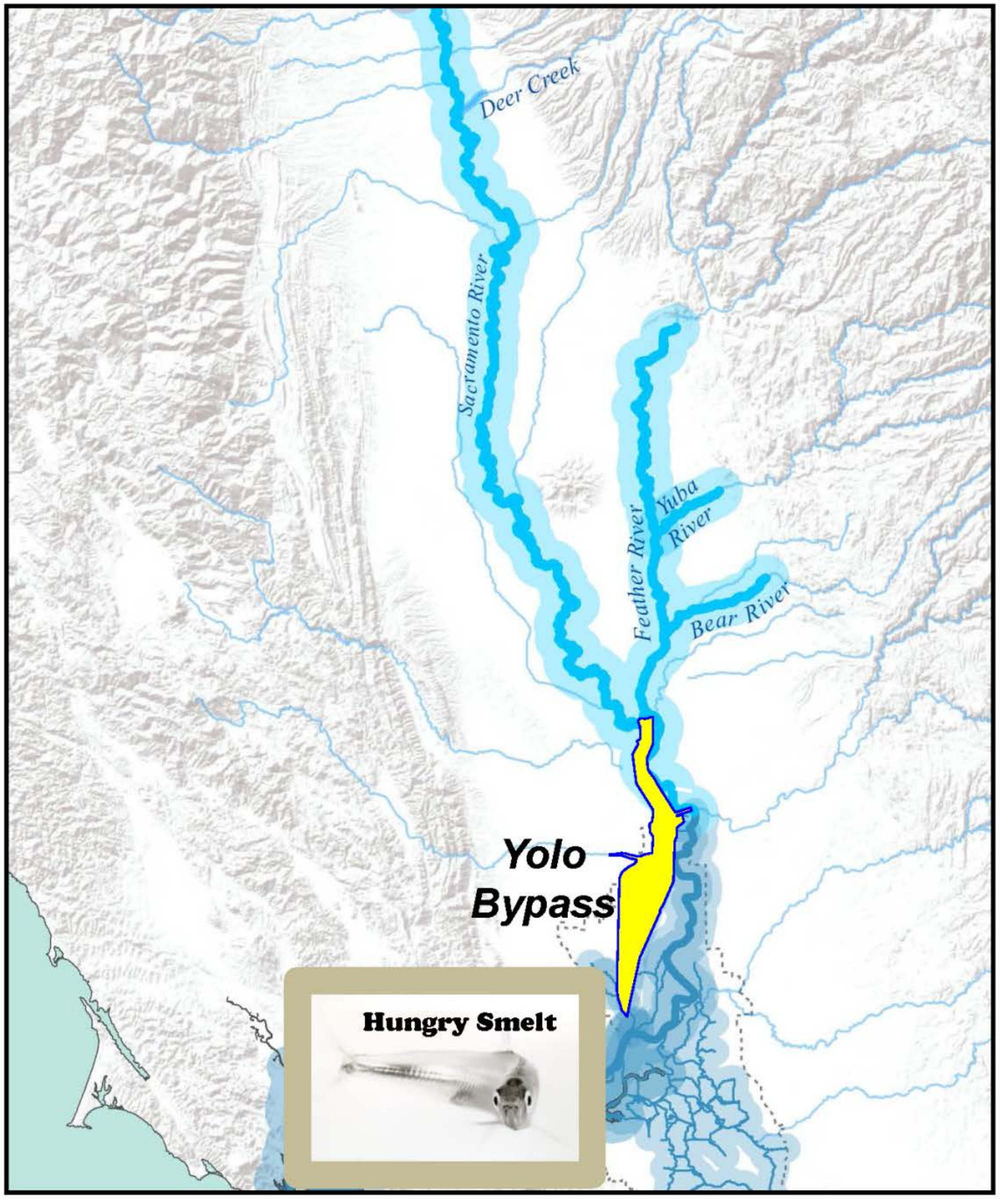
PHASE: 1
VERSION: A
PURPOSE: PHYSICAL PUBLIC BENEFITS ECOSYSTEM PRIORITIES A2
CHECKER: J HERRIN
DATE: 2017 AUGUST
CAVEAT:
QA/QC:
REF/FILE #: WSIP APPLICATION
NOTES:



Evidence That Enhancing Flows Might Help
Unusually High Fall Yolo Flows = Delta Bloom
Knights Landing
Ridge Cut
Sacramento
Feather R.
Cache Creek
River
Yolo
Bypass
Willow Slough Bypass
Hwy I-80
Sacramento
Putah Creek
Rio Vista
5 0 5 10 15
Kilometers
2012 North Delta Phytoplankton Bloom
Flow Pulse
Delta Bloom
Net Flow (cfs)
1000
800
600
400
200
0
-200
Chlorophyll (µg/L)
20
15
10
5
0
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov



Delta Smelt Food Web Flow Action – Summer 2016

Project Coordination

Base map courtesy of NOAA Fisheries

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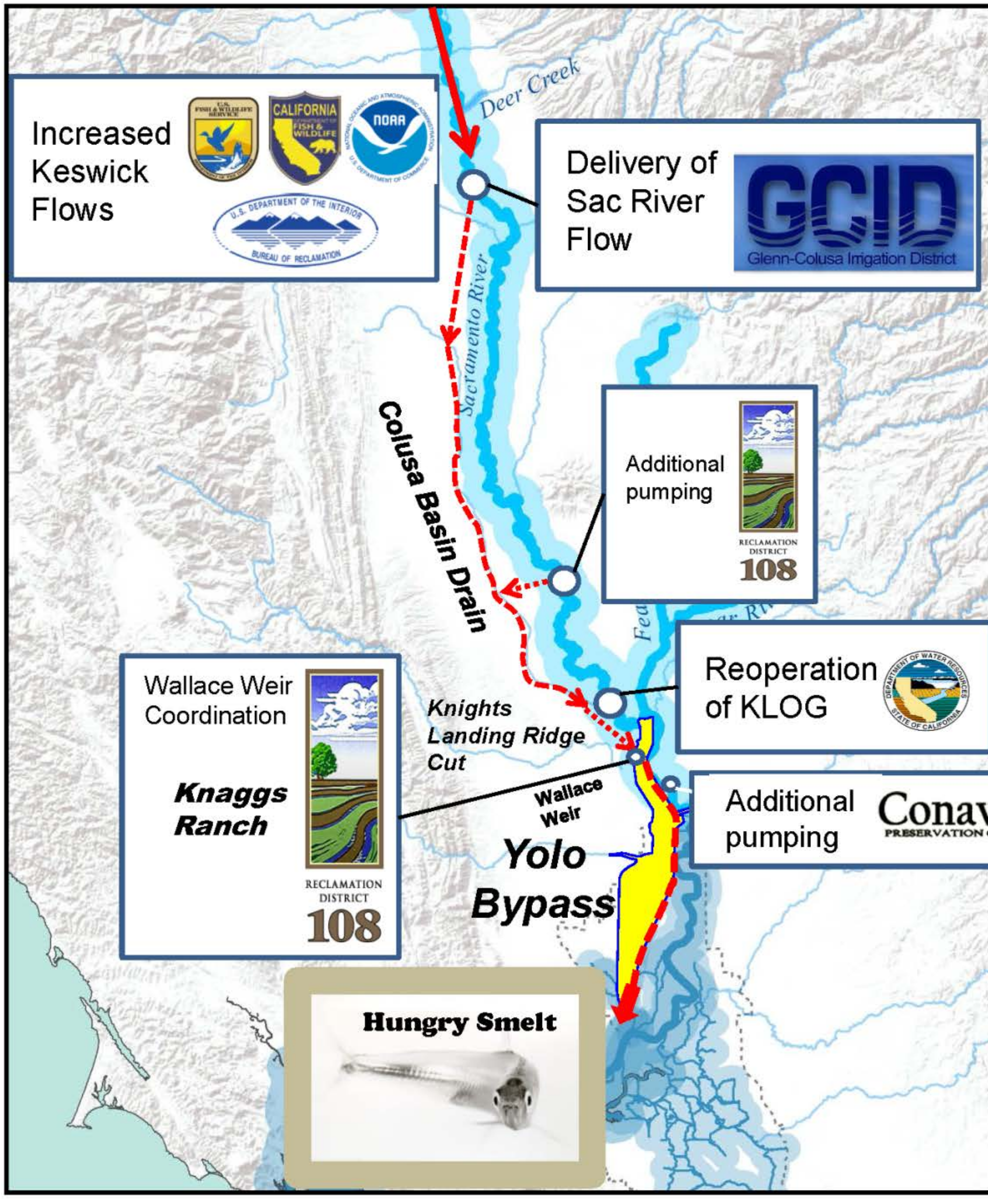
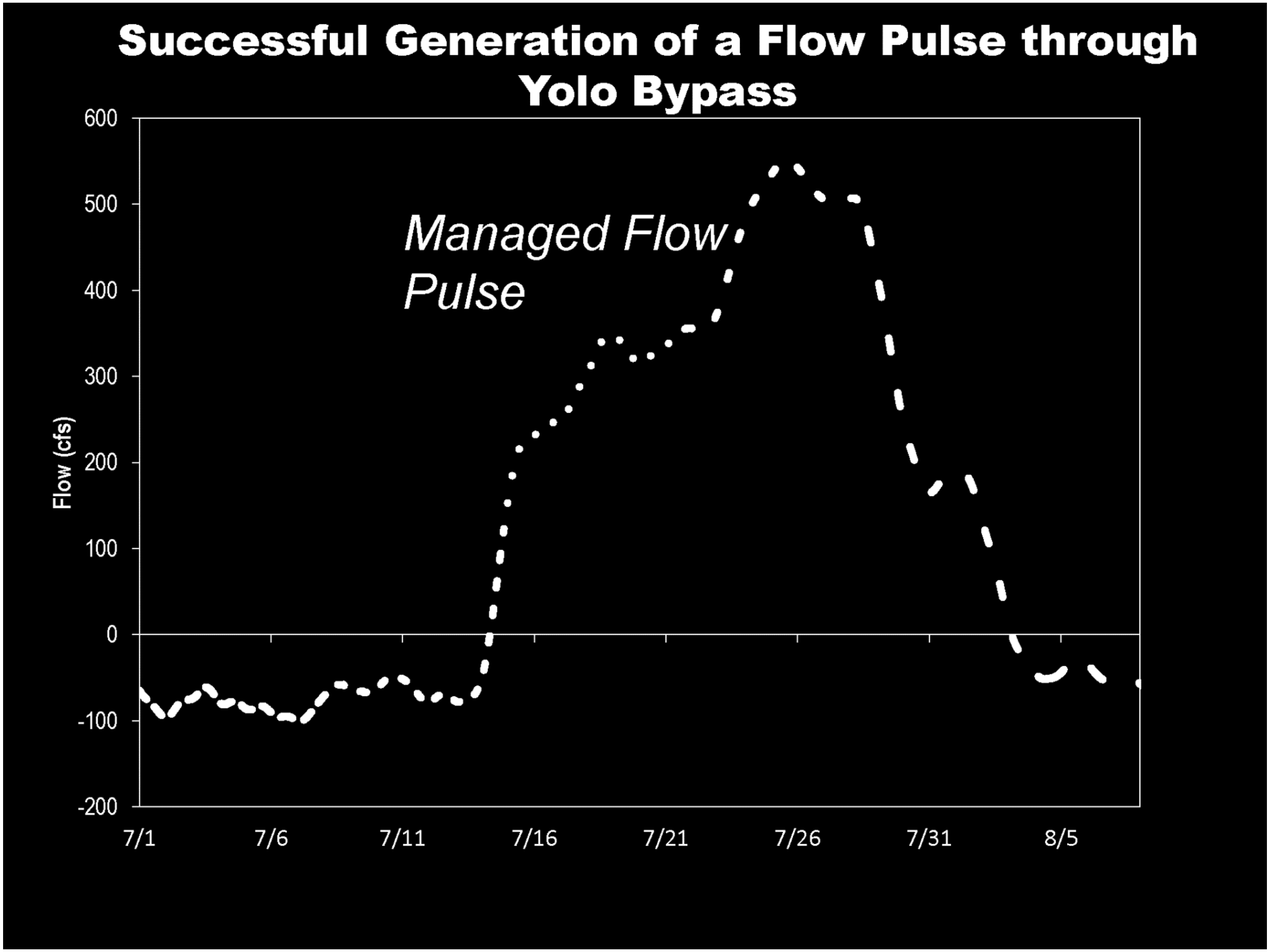
PURPOSE:	PHYSICAL PUBLIC BENEFITS ECOSYSTEM PRIORITIES A2	CHECKER:	J HERRIN	DATE:	2017 AUGUST		
CAVEAT:		QA/QC:		REF/FILE #:	WSIP APPLICATION		
NOTES:				PAGE:	20	OF	44



Delta Smelt Food Web Flow Action – Summer 2016

Project Coordination

Base map courtesy of NOAA Fisheries


Successful Generation of a Flow Pulse through Yolo Bypass
Managed Flow Pulse
Flow (cfs)
600
500
400
300
200
100
0
-100
-200
7/1
7/6
7/11
7/16
7/21
7/26
7/31
8/5

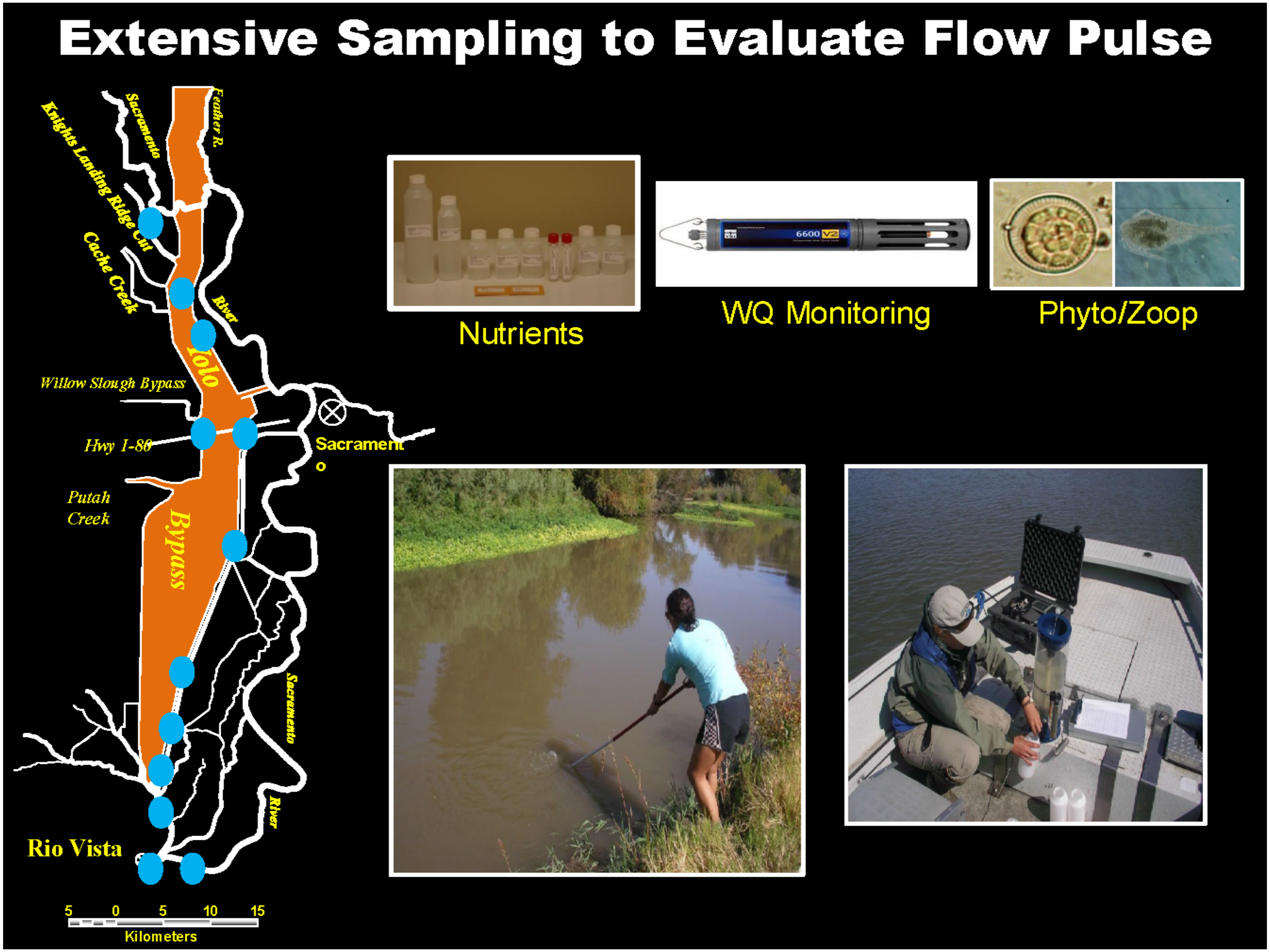
Delta Smelt Flow Action: Study Team

<u>Field Coordination: Jared Frantzich</u>
Flow
Water quality
Plankton

Zooplankton: Kimmerer

Water quality: Bergamaschi, Downing
Invertebrates: Feyrer
Contaminants: Orlando
Benthos: Thompson

<u>Funding</u>
Dept Fish and Wildlife
Dept Water Resources
US Bureau of Reclamation
State and Federal Water Contractors Association



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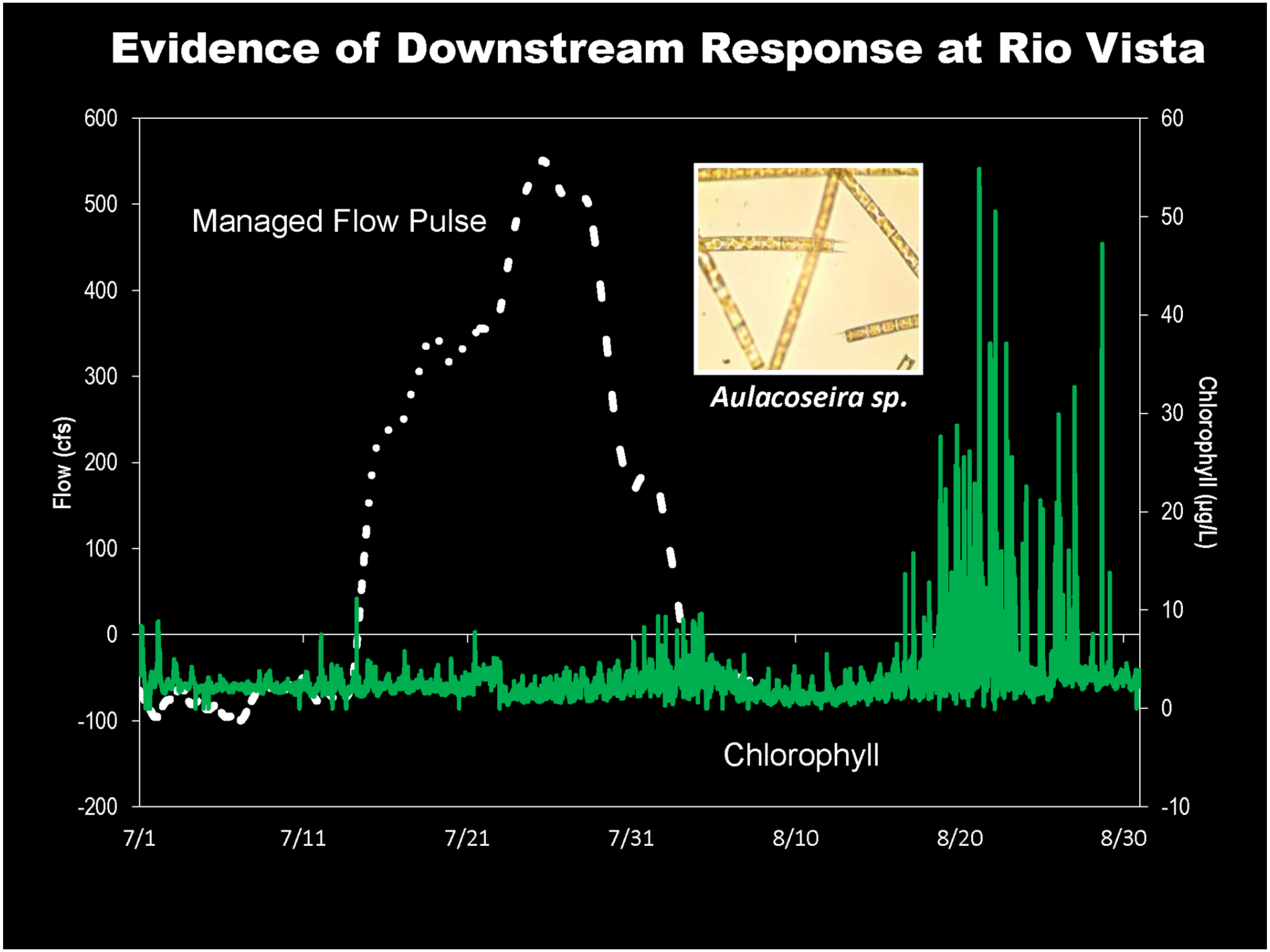
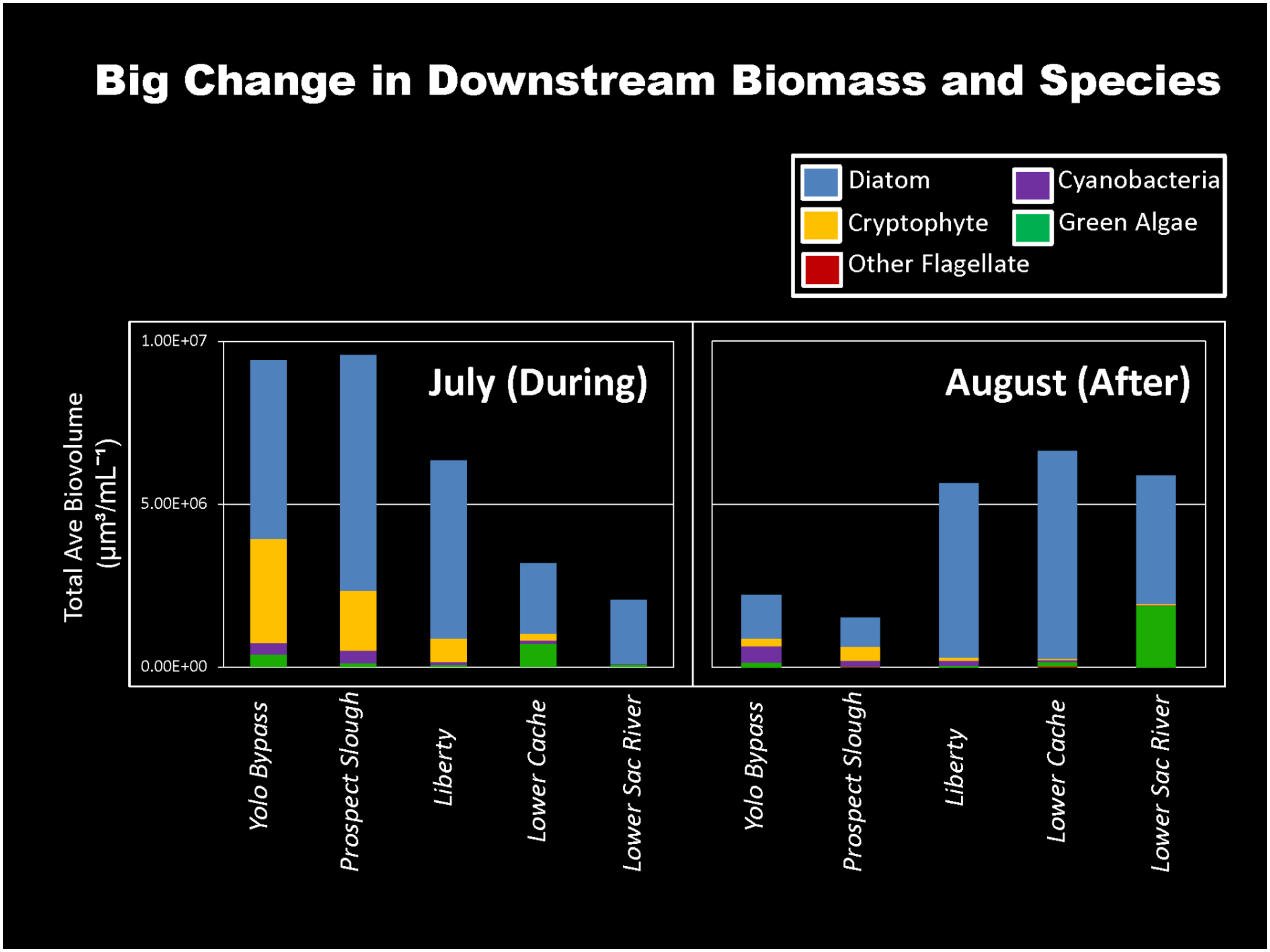
PURPOSE: PHYSICAL PUBLIC BENEFITS ECOSYSTEM PRIORITIES A2
CAVEAT:
NOTES:

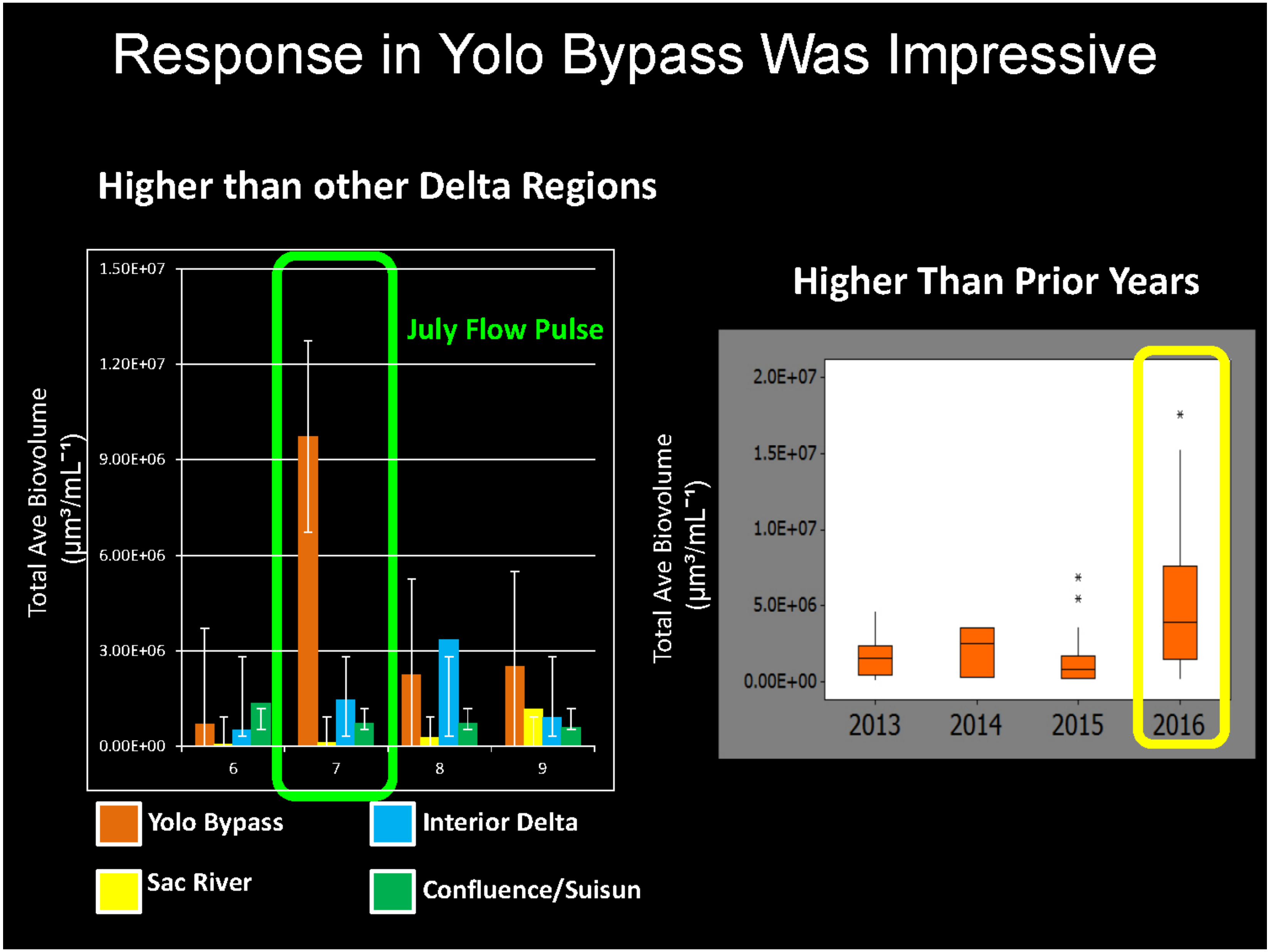
PREPARER: N PONFERRADA
CHECKER: J HERRIN
QA/QC:

PHASE: 1 VERSION: A
DATE: 2017 AUGUST
REF/FILE #: WSIP APPLICATION

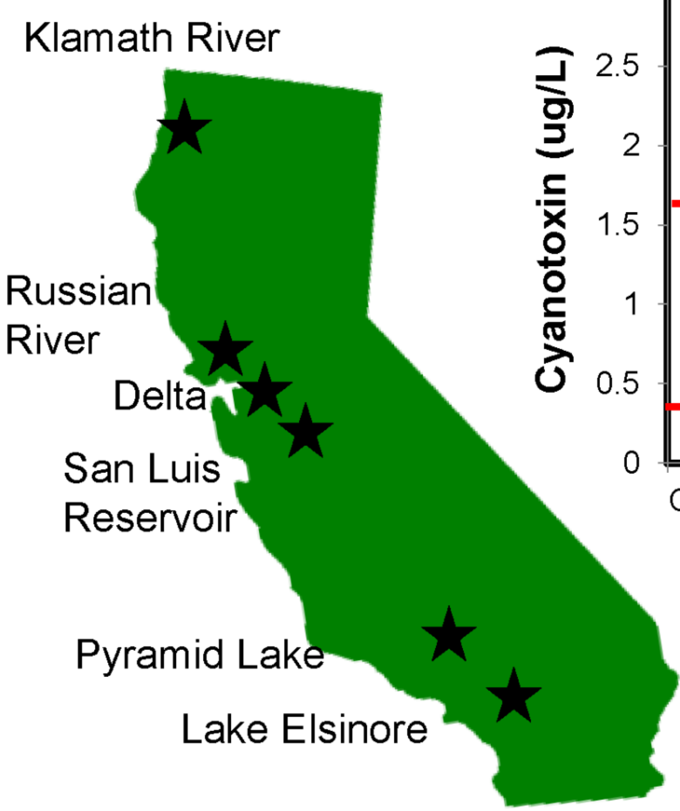


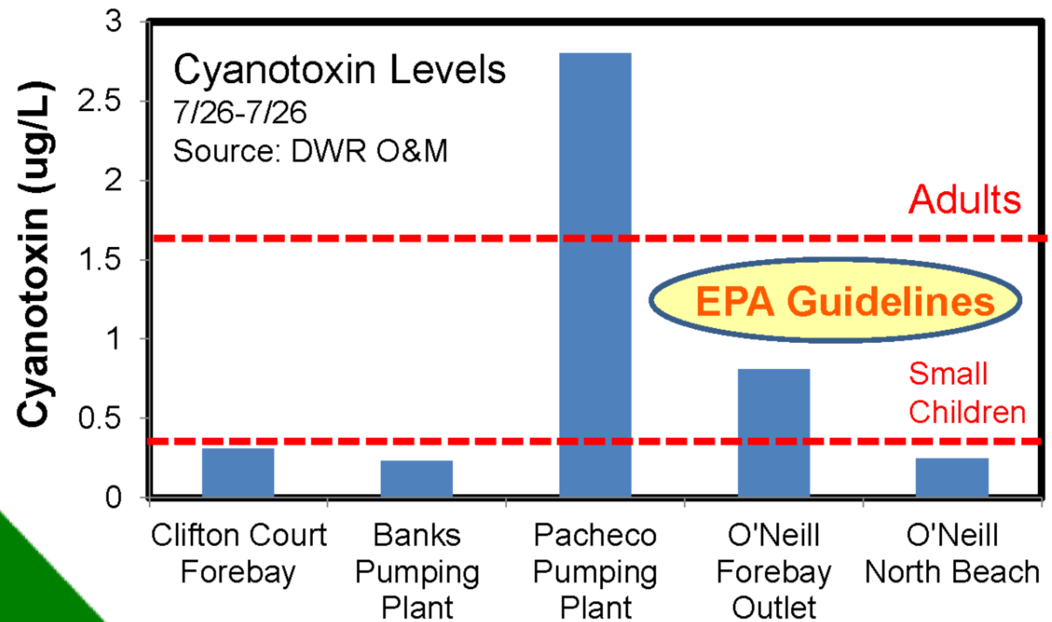
Evidence of Downstream Response at Rio Vista
Managed Flow Pulse
Aulacoseira sp.
Chlorophyll
Flow (cfs)
Chlorophyll (µg/L)
600
500
400
300
200
100
0
-100
-200
60
50
40
30
20
10
0
-10
7/1
7/11
7/21
7/31
8/10
8/20
8/30

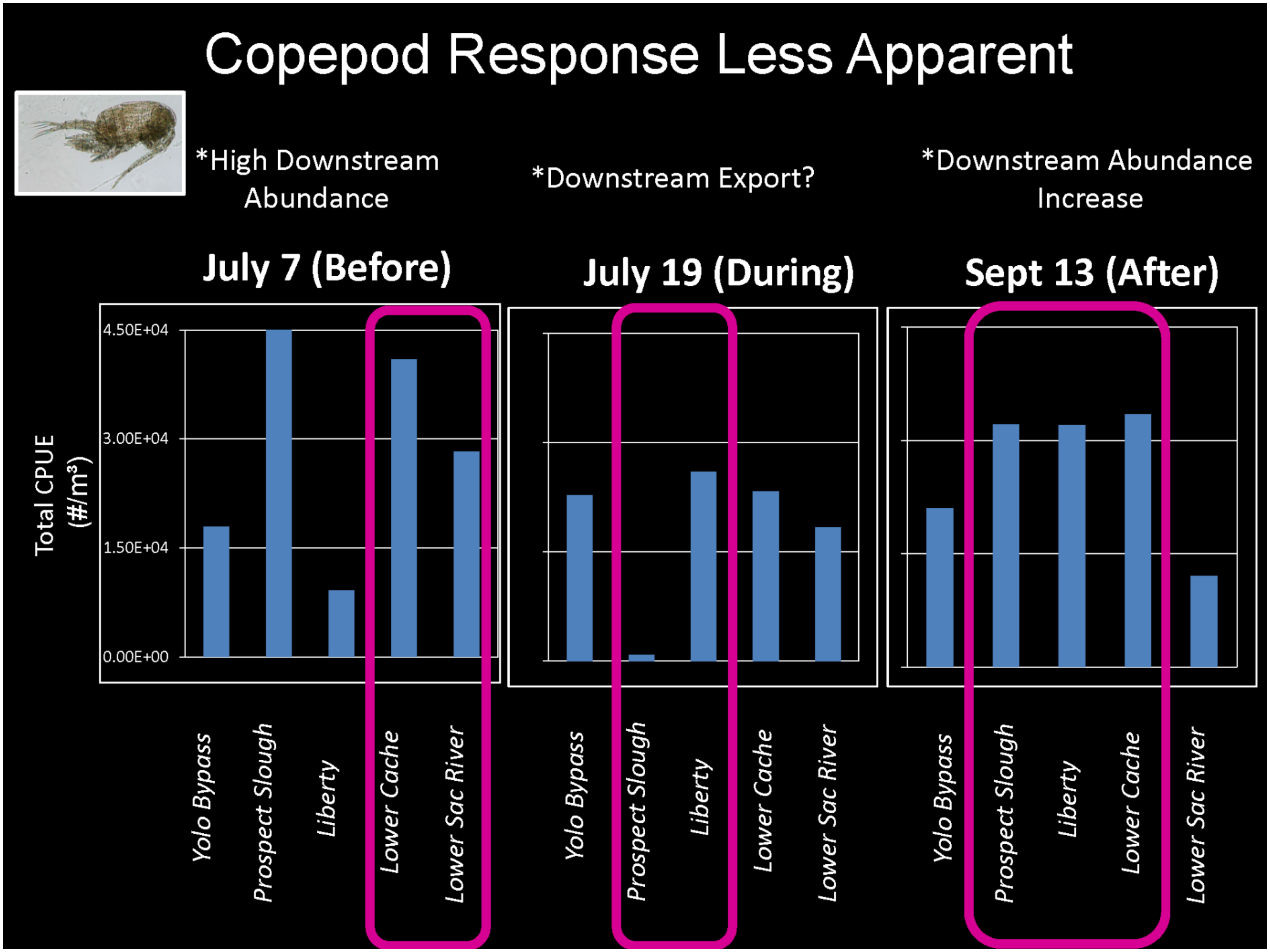

Big Change in Downstream Biomass and Species
Diatom
Cyanobacteria
Cryptophyte
Green Algae
Other Flagellate
Total Ave Biovolume (µm³/mL⁻¹)
1.00E+07
5.00E+06
0.00E+00
July (During)
August (After)
Yolo Bypass
Prospect Slough
Liberty
Lower Cache
Lower Sac River
Yolo Bypass
Prospect Slough
Liberty
Lower Cache
Lower Sac River


Response in Yolo Bypass Was Impressive
Higher than other Delta Regions
1.50E+07
1.20E+07
9.00E+06
6.00E+06
3.00E+06
0.00E+00
Total Ave Biovolume (µm³/mL⁻¹)
6
7
8
9
July Flow Pulse
Yolo Bypass
Interior Delta
Sac River
Confluence/Suisun
Higher Than Prior Years
2.0E+07
1.5E+07
1.0E+07
5.0E+06
0.00E+00
Total Ave Biovolume (µm³/mL⁻¹)
2013
2014
2015
2016

Contrast With Harmful Algal Blooms Elsewhere



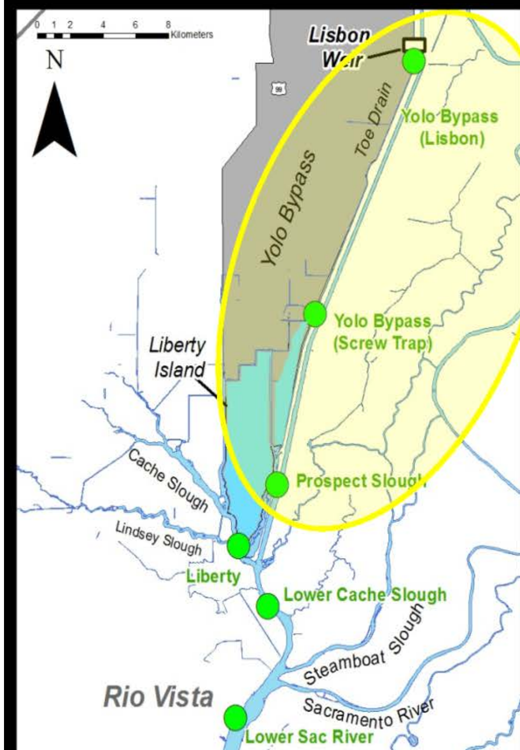


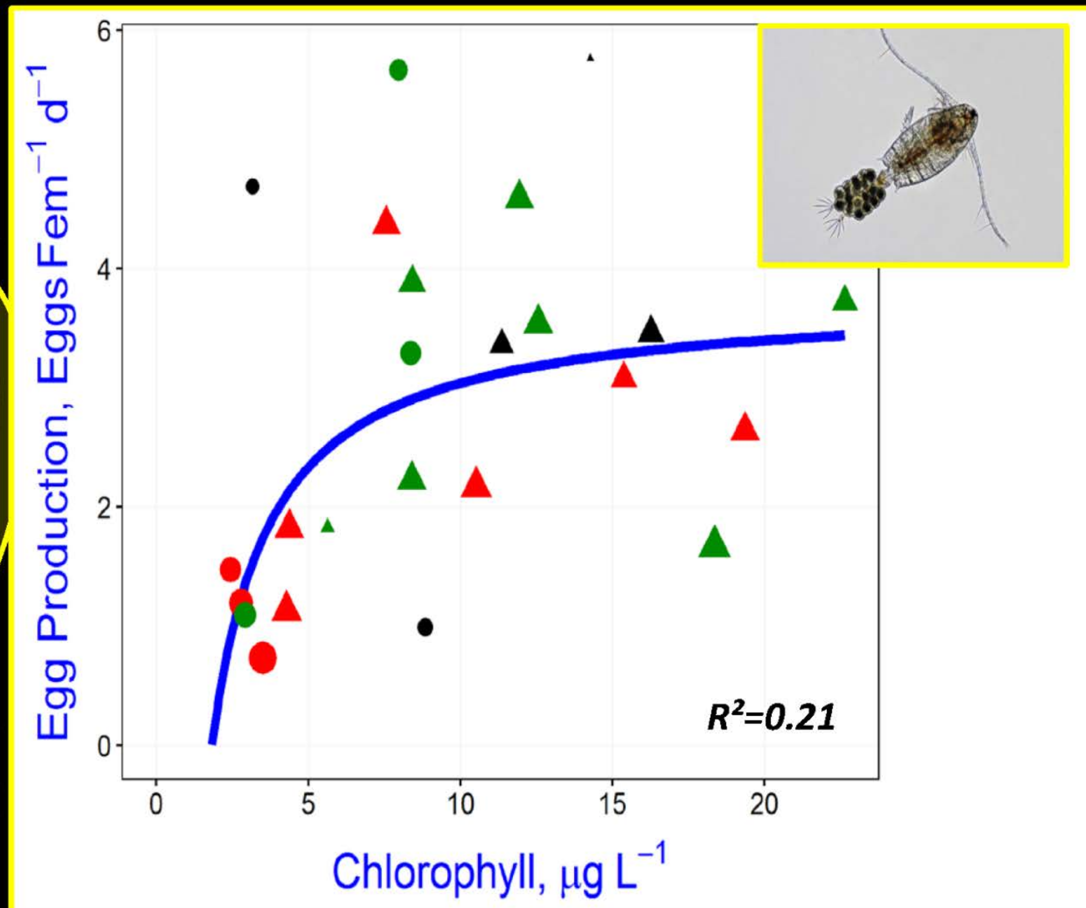

Copepod Response Less Apparent
*High Downstream Abundance
*Downstream Export?
*Downstream Abundance Increase
July 7 (Before)
July 19 (During)
Sept 13 (After)
Total CPUE (#/m³)
4.50E+04
3.00E+04
1.50E+04
0.00E+00
Yolo Bypass
Prospect Slough
Liberty
Lower Cache
Lower Sac River

But…Evidence That Food Increased Copepod Egg Production

ROMBERG TIBURON CENTER for ENVIRONMENTAL STUDIES

SF STATE





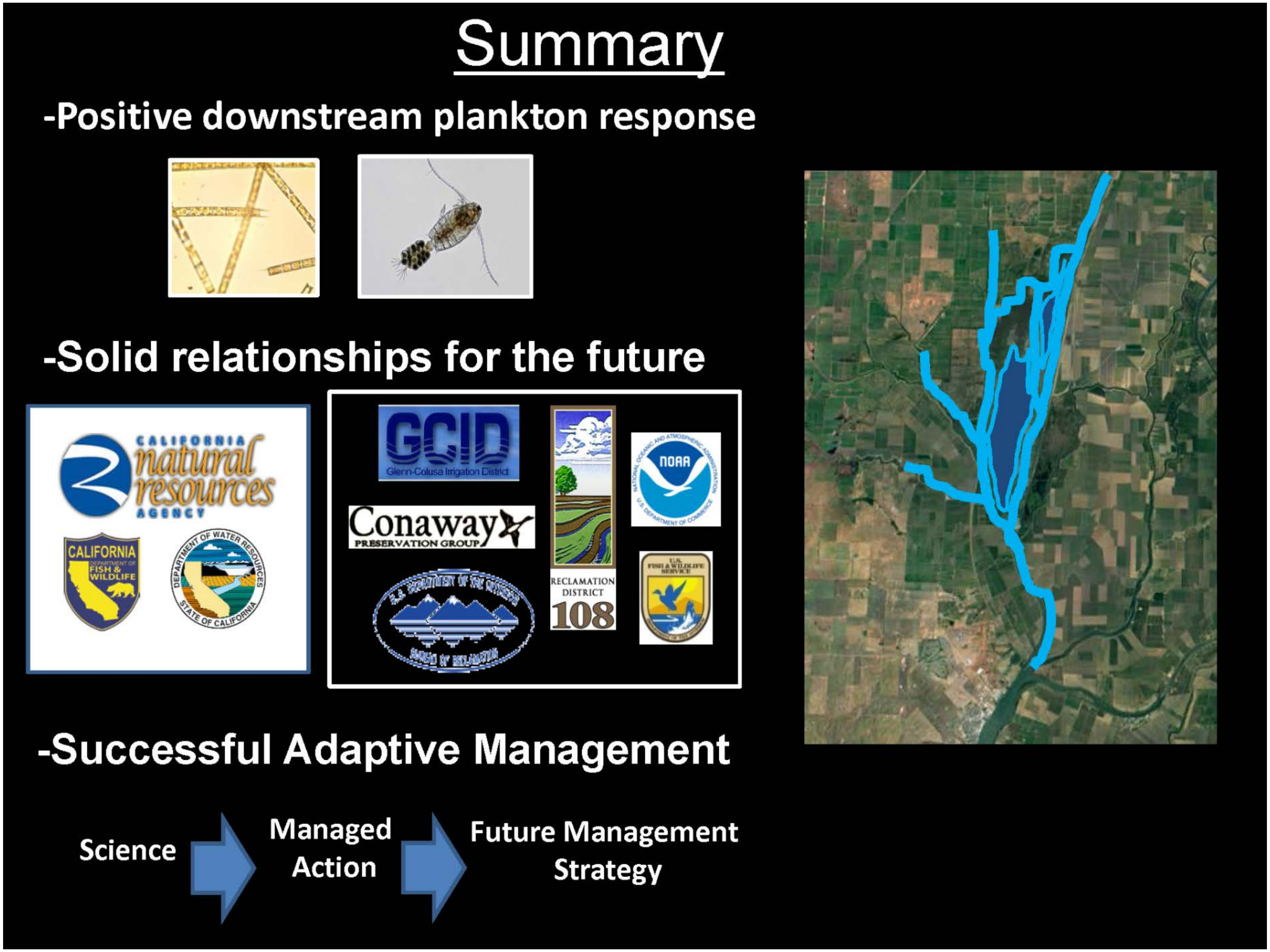
2015 & 2016 Results

Good Media Coverage of the Action

Future Plans

- Planning Efforts for 2017 Summer/Fall Flow Pulse

- Increased Project Funds for FY 2017 and 2018


Summary
-Positive downstream plankton response
-Solid relationships for the future
CALIFORNIA natural resources AGENCY
CALIFORNIA DEPARTMENT OF FISH & WILDLIFE
DEPARTMENT OF WATER RESOURCES STATE OF CALIFORNIA
GCID
Glenn-Colusa Irrigation District
Conaway PRESERVATION GROUP
NOAA
RECLAMATION DISTRICT 108
-Successful Adaptive Management
Science
Managed Action
Future Management Strategy

Ecosystem Priority 14: Ecosystem Priorities Application Worksheet– Terrestrial

Effects of Water Reductions at Refuges:

Reduction in water allocations of 50% to 25% of normal deliveries at Sacramento, Colusa and Delevan NWRs during dry or critically dry years would have the following impacts on wetland habitat and wetland dependent species (source: Drought Contingency Plans for Sacramento, Colusa and Delevan NWRs - USFWS 2011a, 2011b, 2011c).

For 50% of normal deliveries, wetland acreage at the three refuges would be reduced by 30–50%. Composite acreages of seasonal and permanent wetlands at all three refuges totals 15,525 acres (based on 2010 data), which includes 13,722 acres of seasonal wetlands (timothy grass and water grass) and 1,803 acres of permanent and semi-permanent wetland/brood ponds. A 30–50% reduction for permanent and seasonal wetlands would amount to a loss of 4,658 to7,762 acres. For 25% of normal deliveries, total wetland acreage at the three refuges would be reduced by 60-70%, amounting to loss of 9,315 to 10,867 acres. In addition to the direct loss of wetlands, longer term impacts would also occur to future wetland habitat quality throughout the refuges. Loss of permanent pond acreage would be 80% for both the 50% and 25% reductions of normal deliveries. Other impacts on wildlife of reductions to 50 to 25% of normal deliveries include:

- Very early spring draw-downs of wetlands which severely limits shorebird habitat and results in poor germination for important wildlife and waterfowl plants.
- Loss of permanent pond acreage adversely affects habitat for special-status species such as giant garter snakes, tricolored blackbirds, western pond turtles, and for duck broods.
- Complete elimination of irrigation for annual food plants and control of invasive species such as cocklebur, resulting in increased mowing/diesel fuel consumption to mitigate.
- Flood-ups delayed on remaining acreage, resulting in widespread crop depredation in nearby agricultural lands.
- Extreme waterfowl crowding and disease risk (avian botulism (Type C) and avian cholera).
- Reduced public use on all refuge habitats reduced (or eliminated for 25% of water delivery scenario) other than having the Sacramento National Wildlife Refuge (NWR) visitor center open, and visitor use would decrease to a fraction of normal.

Value of Ricelands to Wildlife

The Central Valley of California supports one of the largest concentrations of wintering waterfowl in the world, despite loss of 90% of its historic wetlands. The 6–7 million waterfowl that winter annually in the Central Valley rely upon a mix of wetland and agricultural food resources to meet their energetic needs (Eadie et al. 2008, Petrie et al. 2016). Flooded rice fields and surrounding refuge wetlands in the Sacramento-San Joaquin Valley function as some of the most important waterfowl wintering habitat on the Pacific Flyway, supporting the majority of Flyway population in some years (Migratory Bird Conservation Partnership 2014). Ricelands are indispensable components of waterbird habitat; residual rice, weed seeds, and invertebrates provide food for many avian species during fall and winter (Eadie et al. 2008). Ricelands also provide breeding habitat for a variety of birds, and rice fields that are flooded after harvest (i.e., winter flooded) to decompose rice straw provide many of the same habitat values for waterfowl as the wetlands that they replaced. Droughts adversely affect foraging habitat for wildlife that depend on Central Valley seasonal wetlands and ricelands. An analysis by Petrie et al. (2016) found that in droughts food supplies could be exhausted for ducks by mid- to late winter and by late winter or early spring for geese. For ducks, these results were strongly related to projected declines in winter-flooded rice fields that provide 45% of all the food energy available to ducks in the Central Valley in non-drought water years (Petrie et al. 2016).

CalSim Model Runs - Refuges

Table A2-6 summarizes CalSim II Model Runs conducted on June 21, 2017 and show the net increase in water supply available for all refuges with implementation of the project.

Table A2-6. Difference: WSIP 2030 With Project minus WSIP 2030 Without Project, Refuge Water Supplies (Central Valley Project [CVP] Contract, Sites and Acquisitions Supplies), Long-term Average and Average by Water Year Type

	Total Refuge L2 (Mar–Feb TAF)	Total Refuge L4 (Mar–Feb TAF)
Long-term		
Full Simulation Period[1]	8	35
Water Year Types[2]		
Wet (30%)	3	53
Above Normal 15%	3	47
Below Normal 21%	9	38
Dry 20%	14	21
Critical 15%	11	1

[1] Based on the 82-year simulation period
[2] As defined by the Sacramento Valley 40-30-30 Index Water Year

Deliveries of additional Level 2 and Level 4 water during dry and critically dry years would avoid loss of up to 10,867 acres of wetland habitat on the Sacramento, Colusa, and Delevan NWRs, and the other direct and indirect impacts of reduced water availability described above.

Refuges in the Mendota Pool and the Tulare Basin could also benefit from additional deliveries from the Sites Project. Refuges in these areas include the Kern and Pixley NWR and the CDFW Mendota Wildlife Area. Additional water supply is needed to meet the goals and objectives outlined in the Comprehensive Conservation Plan for Kern and Pixley National Wildlife Refuges (USFWS 2005) and also to improve management of seasonal and permanent wetlands in the Mendota Wildlife Area. Table A2-7 summarizes the results of CalSim II Model Runs that shows the average increased availability of water for refuges and other beneficiaries in the Mendota Pool and Tulare Basin in 2030 with the project, and also the increased water supply available during dry and critically dry years.

Table A2-7. Difference: WSIP 2030 With Project minus WSIP 2030 Without Project for Sites Deliveries of Incremental Level 4 Refuge

Modeled Beneficiaries	Average Increase in Deliveries (TAF/yr)	Dry and Critical Increase in Deliveries (TAF/yr)
Mendota Pool	28	10
Tulare Basin	6	2

CalSim Model Runs - Ricelands

As shown in Table A2-8 and Table A2-9, additional water would be available to support rice plantings in dry and critically dry years with the project. Table A2-8 and Table A2-9 summarize CalSim II Model Runs conducted on June 21, 2017 and show the net increase in water supply available for agricultural users in the Central Valley with implementation of the project.

Table A2-8. Difference: WSIP 2030 With Project minus WSIP 2030 Without Project Sites Deliveries to Sacramento Valley Members: Long-term Average and Average by Water Year Types

Analysis Period[1]	**Sacramento Valley (Mar–Feb TAF)**
Long Term	
Full Simulation Period	129
Water Year Type	
Wet (30%)	62
Above Normal 15%	118
Below Normal 21%	155
Dry 20%	186
Critical 15%	165

Table A2-9. Difference: WSIP 2030 With Project minus WSIP 2030 Without Project Sites Deliveries to South of Delta Members for Agriculture: Long-term Average and Average by Water Year Types

Analysis Period[1]	**Jan-Dec, TAF)**
Long Term	
Full Simulation Period	23
Water Year Type	
Wet (30%)	2
Above Normal 15%	-1
Below Normal 21%	23
Dry 20%	52
Critical 15%	50

[1] Based on the 82-year simulation period

[2] As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (State Water Resources Control Board [SWRCB] D-1641, 1999)

[3] Includes Sites delivery to Tehama-Colusa Canal Authority (TCCA) members, Glenn Colusa Irrigation District (GCID), RD108, County of Colusa, and Western Canal Water District

Ecosystem Priority 15: Develop and Implement Invasive Species Management Plans

Consistent with this priority, the Authority will create habitat in the vicinity of reservoir on lands that are not accessible to the public. This area is currently covered with yellow star thistle (*Centaurea solstitialis*) and goatgrass (*Aegilops triuncialis*). The yellow star thistle will be eliminated and replaced with species characteristic of native California prairie.

Central Valley Prairie

Figure A2-3: Virgate tarplant

Plant Composition: Burcham (1957) mapped most of "pristine California Prairie" in the Central Valley before agriculture had converted most of this habitat to cropland. His mapping matches the early Valley's accounts by John Muir who described the California Central Valley (CV) Prairie as a sea of wildflowers with little grass. He identified numerous colorful forbs from the genera of Layia, Lasthenia, Lupinus, and Eschscholzia dominating the prairie in spring, and a second late summer domination by flowering forbs like virgate tarplant (*Holocarpha virgata*) and its other Asteraceae relatives. Additionally, there are summer blooming perennials like narrow-leaved mule's ears (*Wyethia angustifolia*) and perennial lupine (*Lupinus formosus*) that survive in CV Prairie relic areas where purple needlegrass (*Stipa pulchra*) would be expected.

Extent: Since Burcham's mapping, much of the CV Prairie habitat was lost to urbanization and cultivation. The CV Prairie closely corresponds with the extent of California Grassland habitat in the Central Valley.

Soils: Prairie soils do not support trees and shrubs because their hardpans and clay horizons keep most water too close the soil surface. Some believe California prairie was once covered by bunchgrasses (which are now uncommon), but there is little documentation or evidence for this belief. In fact annual wildflowers covered the floor of the Valley. California Central Valley Prairie typically occurs on alluvial valley soils that favor herbaceous vegetation because of their fine texture and often abundant clay. Before urbanization and cultivation, CV Prairie primarily occurred on "*recent alluvium*", so named by geologists because it was deposited during the 10,000 years since the last Ice Age. However, because of the high fertility and low relief, this soil type became the prime land for agriculture and development. Currently the last extant areas of CV Prairie are now found on "*older alluvium*" that was formed from 10,000 to 2 million years ago. Soils in these areas are coarser, less fertile, hillier, and farther from the Valley center. As a result of that, these areas are less often cultivated or urbanized and are very often used for grazing, a land use that in some cases preserves native prairie plants.

The CV Prairie fine and clayey soils are a great substrate for rhizomatous grasses and shallow rooted annual species because they can densely cover its moist and fertile surface. In contrast, coarse and sandy soils favor deep and wide extending roots of bunch grasses, trees and shrubs because water and air can penetrate freely, however, water and nutrients are scarce near the surface.

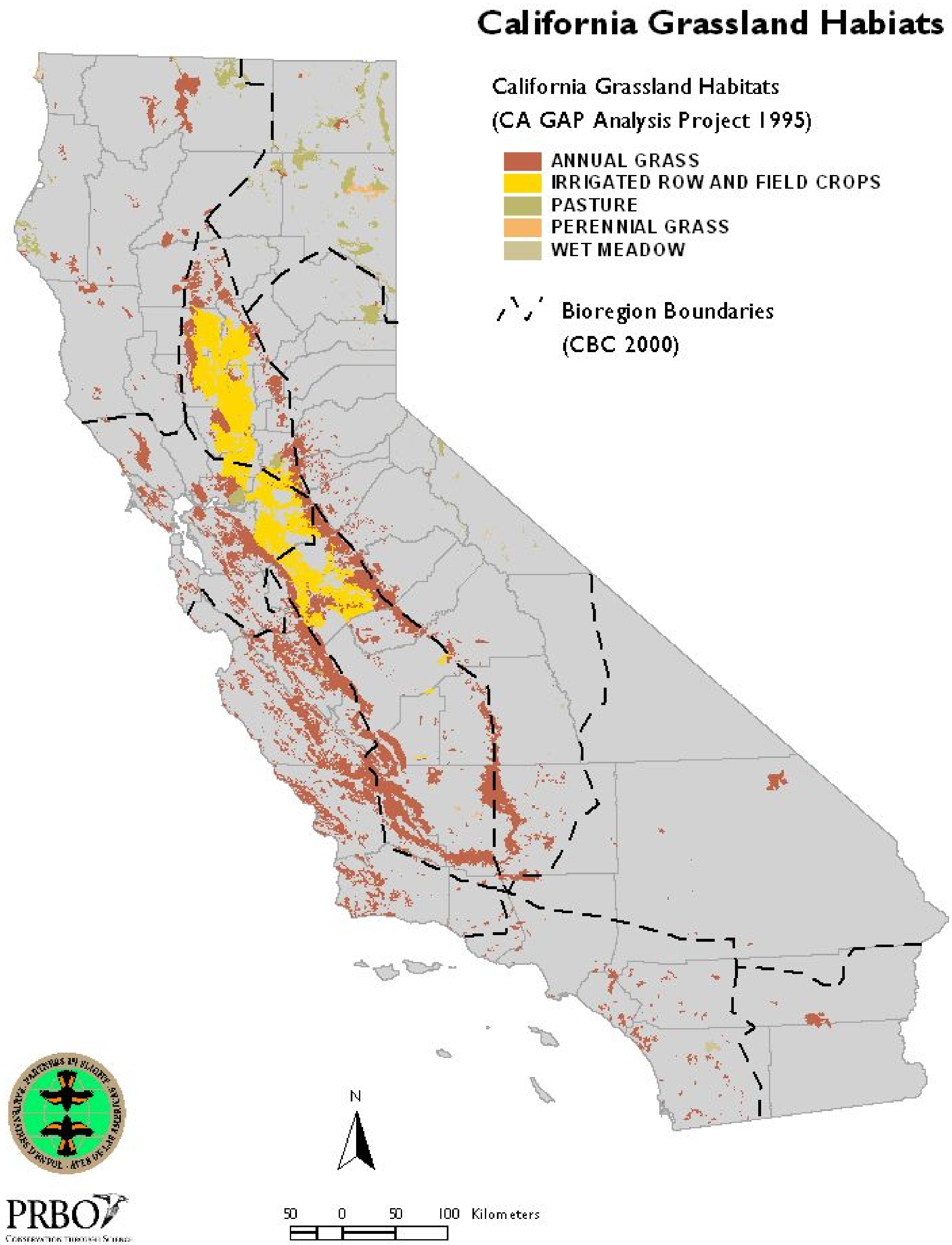


Figure A2-4 California Grassland Habitats mapped in 1995 by the GAP Analysis Project

Plants: The CV Prairie differs from other prairies of the world in both identity of the perennial species and the larger number and the importance of annuals (Beetle 1947). Typical fine clayey soils of the CV Prairie would have the creeping wildrye (*Leymus triticoides*) as a dominant grass species along with large number of annual forbs such as California poppy (*Eschscholzia californica*), purple owl clover (*Orthocarpus purpurascens*), virgate tarplant, tidytips (*Layia platyglossa*), narrowleaved mule's ears (*Wyethia angustifolia*), perennial lupine (*Lupinus formosus*), Ithuriel's spear (*Triteleia laxa*), tomcat clover (*Trifolium willdenovii*), gilia (Gilia tricolor), (*Orthocarpus erianthus*), blue-eyed grass (*Sisyrinchium bellum*), and various other species of the genera *Layia*, *Brodiaea*, *Calandrinia*, *Nemophila*, *Castilleja*, and *Lupinus*. On the marginal coarse soils along the edges of the valley, bunchgrasses such as purple needlegrass (*Stipa pulchra*), and nodding needlegrass (*Stipa cernua*), were dominant along with important associates such as blue wildrye (*Elymus glaucus*), pine bluegrass (*Poa scabrella*), and deergrass (*Muhlenbergia rigens*).

Central Valley Prairie Importance

Despite the fact that the CV Prairie provides critical foraging habitat for the golden eagle, nesting and feeding habitat for native bees, refuge borrows for amphibians, and habitat for rich native flora and fauna, CV Prairie does not receive as much attention as the often adjacent vernal pool and riparian habitats for which it serves as an important buffer.

Habitat for Native Plant Diversity: The CV Prairie provides the optimal habitat for hundreds of native plant species that have adapted to the fine clayey soils and high water table in these areas.

Golden Eagle Foraging Habitat: Golden Eagles live in open and semi-open country featuring native vegetation across most of the Northern Hemisphere.

Plant Pollinator Habitat: The spring growth of native forbs represents a tremendous food resource for pollinators. Bees, bumblebees, beetles, hummingbirds, bats, butterflies, moths, and flies are some of the pollinators needed by 90% of flowering plants and over 30% of food crops (Pollinator Partnership 2010). CV Prairie provides food and shelter for bees and other insects that pollinate our food crops. The importance of these native pollinators, especially ground and twig nesting bees, is increasing due to the current collapse of populations of the European honeybee.

Central Valley Prairie Creation Approach

Site Preparation: In areas where residual native species cover is present, it will be preserved. At the same time invasive species will be controlled and additional native species seeded. However, very often, there are virtually no residual native plants at heavily grazed sites and the "blank slate" restoration approach will be adopted if that is the case at the Sites Reservoir restoration areas. The soil texture, compaction, profile and chemistry, as well as hydrology will be closely analyzed during this phase to determine the best composition of native plant species to be seeded.

Existing Weed and Weed Seedbank Removal: Non-native vegetation eradication involves removal of the existing exotic species to the greatest extent possible (including the seed bank) and installing a native plant community from seed. Typically, existing vegetation eradication consists of three to four times repeated shallow tilling and irrigation cycles to exhaust the seed bank followed by re-seeding with native vegetation. Hard to eradicate weed species such as the yellow star thistle (*Centaurea solstitialis*) and goatgrass (*Aegilops triuncialis*) a more intense eradication methods such as burning, solarization and as a last resort herbicide spraying may be used. It will be also very important to control these invasive species in weed infested areas adjacent to and up-wind of the project. Increasing the cover and diversity of native forbs - either by actively planting them or by removing the invasive species with which they compete— will greatly contribute to the restoration success. As one example, hayfield tarplant (*Hemizonia congesta*) is often added to a native bunchgrass seed mix specifically to armor restored grasslands against re-invasion by yellow star thistle because it is the greatest impediment to successful grass establishment. Annual applications of a broadleaf herbicide are also often necessary to keep it at bay. While herbicides are effective, an ecosystem that depends on regular herbicide application does not meet the definition of self-sustaining. A promising technique for providing natural invasion resistance to restored grasslands is to select native species that compete strongly for the same resources as likely invaders (Young et al. 2009). Native tarplants are among the grassland species most analogous to yellow star thistle in the timing of growth and seed set. These late-season annual forbs germinate with the first fall rains and spend the winter and spring developing a tap root. Doing so allows them to take advantage of deep soil moisture in the summer and to flower and set seed long after the majority of annuals have completed their life cycle. Yellow star thistle is more effectively eliminated if a diversity of native late season forbs is planted that compete for resources with the thistle in slightly different ways. As another example, effective control of the invasive annual barbed goatgrass (*Aegilops triuncialis*) with analogous native species results in a natural resurgence of native forbs and a corresponding increase in the activity of native bees.

Seed Collection and Seeding: Because disturbed CV Prairie usually lacks any significant native seed bank, restoring prairie will require the reseeding of native species. Native species should be collected from the nearest vicinity around Sites Reservoir and can be seeded either manually with belly grinders, by the hydro-mulching method or with seed-drillers if the amounts of seed are small. Seed collection should be initiated immediately after project start so that sufficient seed amounts and diversity are available at the time of installation. The traditional approach to prairie restoration emphasizes the establishment of native bunch grasses. Following site preparation, a seed mix of up to seven native grass species is applied.

Ecosystem Priority 16: Ecosystem Priorities Application Worksheet– Terrestrial

CalSim Model Runs - Refuges

Table A2-10 summarizes CalSim II Model Runs conducted on June 21, 2017 and show the net increase in water supply available for all refuges with implementation of the project.

Table A2-10. Difference: WSIP 2030 With Project minus WSIP 2030 Without Project, Refuge Water Supplies (CVP Contract, Sites and Acquisitions Supplies), Long-term Average and Average by Water Year Type

	Total Refuge L2 (Mar–Feb TAF)	Total Refuge L4 (Mar–Feb TAF)
Long-term		
Full Simulation Period[1]	8	35
Water Year Types[2]		
Wet (30%)	3	53
Above Normal 15%	3	47
Below Normal 21%	9	38
Dry 20%	14	21
Critical 15%	11	1

[1] Based on the 82-year simulation period
[2] As defined by the Sacramento Valley 40-30-30 Index Water Year

Native Species Benefiting from Implementation of the Project

The following native species occur on the Sacramento NWR Complex refuges and have commercial, recreational, scientific, or educational uses and values, and would benefit from implementation of the project:

Table A2-11. Waterfowl

Common Name	*Scientific Name*
Ross's Goose	*Chen rossii*
Snow Goose	*Chen caerulescens*
Green-winged Teal	*Anas crecca*
Gadwall	*Anas strepera*
Cinnamon Teal	*Anas cyanoptera*
Northern Shoveler	*Anas clypeata*
Greater White-fronted Goose	*Anser albifrons*
Northern Pintail	*Anas acuta*
Western Meadowlark	*Sturnella neglecta*
Ruddy Duck	*Oxyura jamaicensis*
American Wigeon	*Anas americana*
Mallard	*Anas platyrhynchos*
Ring-necked Duck	*Aythya collaris*
Lesser Scaup	*Aythya affinis*
Bufflehead	*Bucephala albeola*
Common Goldeneye	*Bucephala clangula*
American Green-winged Teal	*Anas crecca carolinensis*
Canada Goose	*Branta canadensis*
Blue-winged Teal	*Anas discors*

Table A2-12. Shorebirds/Egrets/Other Wetland-Dependent Species

Common Name	***Scientific Name***
American Bittern	*Botaurus lentiginosus*
Common Snipe	*Gallinago gallinago*
Eared Grebe	*Podiceps nigricollis*
Great Egret	*Ardea alba*
American White Pelican	*Pelecanus erythrorhynchos*
Black-necked Stilt	*Himantopus mexicanus*
White-faced Ibis	*Plegadis chihi*
Double-crested Cormorant	*Phalacrocorax auritus*
Great Blue Heron	*Ardea herodias*
Marsh Wren	*Cistothorus palustris*
Western Pond Turtle	*Actinemys marmorata*
Snowy Egret	*Egretta thula*
American Avocet	*Recurvirostra americana*
Killdeer	*Charadrius vociferus*
Common Gallinule	*Gallinula galeata*
Pied-billed Grebe	*Podilymbus podiceps*
Ring-billed Gull	*Larus delawarensis*
Long-billed Curlew	*Numenius americanus*
North American River Otter	*Lontra canadensis*
Greater Yellowlegs	*Tringa melanoleuca*
Virginia Rail	*Rallus limicola*
Clark's Grebe	*Aechmophorus clarkii*
Caspian Tern	*Hydroprogne caspia*
Wilson's Snipe	*Gallinago delicata*
American Herring Gull	*Larus argentatus smithsonianus*

Table A2-13. Special-Status Species

Common Name	***Scientific Name***
Peregrine Falcon	*Falco peregrinus*
Northern Harrier	*Circus cyaneus*
American White Pelican	*Pelecanus erythrorhynchos*
White-faced Ibis	*Plegadis chihi*
Greater Sandhill Crane	*Grus canadensis*
Bald Eagle	*Haliaeetus leucocephalus*
Double-crested Cormorant	*Phalacrocorax auritus*
Tricolored Blackbird	*Agelaius tricolor*
Loggerhead Shrike	*Lanius ludovicianus*
Cooper's Hawk	*Accipiter cooperii*
White-tailed Kite	*Elanus leucurus*
Western Pond Turtle	*Actinemys marmorata*
Giant garter snake	*Thamnophis gigas*

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