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Proposal No.	Region

Section 1: Summary Information

1. Project title:	Evaluation of Floodplain Rearing and Migration in the Yolo Bypass
2. Applicant name:	California Department of Water Resources
3. Contact person:	Ted Sommer, PhD
4. Address:	Department of Water Resources. 3500 Industrial Blvd, 2nd Flr.
5. City, State, Zip:	West Sacramento CA, 95691
6. Telephone #:	916-376-9772
7. Fax #:	916-376-9688
8. Email address:	tsommer@water.ca.gov
9. Agency Type:	Federal Agency ☐ State Agency ☒ Local Agency ☐ Nonprofit Organization ☐ University (CSU/UC) ☐ Native American Indian Tribe ☐
10. Certified nonprofit Organization:	Yes ☐ No ☒
11. New grantee:	Yes ☐ No ☒ Previous recipient of a Cal-Fed Science award.
12. Amount requested:	$878,020
13. Total project cost:	$878,020
14. Topic Area(s):	Primary: At-Risk Species Assessment Secondary: Estuary Foodweb Productivity, Fish Passage, Lowland Floodplains and Bypasses, and Shallow Water and Marsh Habitat.
15. ERP Project type:	Primary: Research Secondary: Monitoring and Planning.
16. Ecosystem Element:	Primary: Essential Fish Habitats Secondary: Bay-Delta Aquatic Food Web, Freshwater Fish Habitat, Tidal Perennial Aquatic Habitat
17. Water Quality Constituent:	N/A
18. At-Risk species benefited:	Central Valley spring-run Chinook spring-run salmon ESU critical habitat; Delta smelt critical habitat; Sacramento River winter-run Chinook spring-run salmon ESU critical habitat; Central Valley fall-/late-fall-run Chinook salmon ESU, Green Sturgeon ESU
19. Project objectives:	Perform research to guide Yolo Bypass restoration actions to enhance passage for migrating adult salmon and sturgeon, and optimize juvenile salmon rearing. Analyze existing salmon and food web data, conduct telemetry, genetics, and physiology studies, and evaluate isotopes for assessing population-wide floodplain use.
20. Time frame:	September 2011-September 2013

Section 2: Location Information

1. Township, Range, Section: and the 7.5 USGS <u>Quad map name</u>.	Study will cover areas included in the following quad maps: Liberty Island, Clarksburg, Saxon, Sacramento West, Davis, Taylor Monument, Grays Bend, Verona, and Knights Landing.
2. Latitude, Longitude (in decimal degrees, Geographic, NAD83):	Northeast boundary 38°45'52.73."N-121°38'7.82"W; Northwest boundary 38°45'33.05."N-121°39'55.35"W; Southeast boundary 38°21'0.70."N-121°38'42.47"W Southwest boundary 38°19'18.76."N-121°41'36.92"W

3. Location description:	The Bypass is a leveed, 59,000-acre floodplain on the west side of the lower Sacramento River in California's Yolo and Solano Counties. Located within the boundaries and levees of the Sacramento River Flood Control Project (FCP), the Bypass is a primary component of the FCP and carries floodwaters from several northern California waterways to the Sacramento–San Joaquin River Delta (Delta). These waterways include the Sacramento, Feather, and American Rivers and their associated tributary watersheds. Tributaries specific to the Bypass include Cache and Putah Creeks, Willow Slough, and the Knights Landing Ridge Cut from the Colusa Basin (Figure 1). Two main geographical sections comprise the Bypass: an upper 14.2-mile section between the Fremont Weir and the Interstate 80 (I-80) causeway (Northern Bypass) and a lower 26.8-mile section (both measured north to south) between the I-80 causeway and the southern end of the Egbert Tract (Southern Bypass). The Northern Bypass is nontidal and is bounded on the east by the Tule Canal (the upper extension of the Toe Drain) and the East Bypass Levee and bounded on the west by the West Bypass Levee. The Interstate 5 (I-5) causeway bisects the Northern Bypass east to west. The Southern Bypass is bounded on the east by the Toe Drain and the East Bypass Levee, downstream to the northwest corner of Prospect Island. At this location, the Bypass extends east to include Prospect Island, although the East Bypass Levee remains intact along the west edge of the island. South of Prospect Island, the east side of the Bypass extends downstream of the confluence of Cache and Lindsey Sloughs to the downstream boundary of Egbert Tract. This eastern downstream limit of the Bypass is roughly located with the confluence of Steamboat and Cache Sloughs. The west side of the Bypass is bounded by the West Bypass Levee to just south of Putah Creek and the Putah Creek Sink downstream of Putah Creek. The Southern Bypass is unleveed on the west side for approximately 8 miles, allowing floodwaters to flow unimpeded as far west as Yolo County Road (CR) 104. Farther downstream (approximately 1 mile north of Yolo CR 155), the West Bypass Levee resumes and extends south and west of Liberty Island. The west side of the Bypass extends farther south, downstream of Liberty Island, and along the western boundary of Egbert Tract.
4. County(ies):	Yolo and Solano counties.
5. Directions:	See *Location description* for relationship between project area and the major roadways.
6. Ecological Management Region:	Alluvial River-Floodplain, Yolo Basin, and Sacramento-San Joaquin Delta
7. Ecological Management Zone(s):	Sacramento-San Joaquin Delta Ecological Management Zone, Sacramento River Ecological Zone, Yolo Basin Ecological Management Zone
8. Ecological Management Unit(s):	North Delta Ecological Unit
9. Watershed Plan(s):	N/A
10. Project area:	Yolo Bypass Floodplain
11. Land use statement:	The area is managed for a mix of uses, flood conveyance for the entire Sacramento Valley, agricultural land, riparian and managed wetland habitats, and some upland and grassland habitats.
12. Project area ownership:	% Private_______ % State__100____ % Federal________ (Work to be conducted during inundation periods)
13. Project area with landowners support of proposal:	Sampling and project activities will be conducted within the Bypass during periods of inundation, easements held through the Sacramento-San Joaquin Drainage District encompass the project area.

Section 3: Landowners, Access and Permits

1. Landowners granting access for project: **(Please attach landowner provisional access agreement[s]):**
The project is based primarily on sampling within navigable waters of the US, which can be access by boat and do not require entry via private property. Most additional sampling or equipment installation will be done on public lands (Yolo Bypass, Sacramento Bypass and Fremont Weir wildlife areas), at agency-operated gauging stations (Lisbon Weir, Cache Creek mouth), or public right of

ways (e.g. Yolo Causeway). Also, we still need to gain access to install telemetry equipment at Wallace Weir (Knight's Landing Ridge Cut) and Willow Slough Bypass from willing landowners or local reclamation districts.	
2. Owner Interest: N/A	
3. Permits:	As Yolo Bypass monitoring work has been sponsored by the Interagency Ecological Program (IEP) for 13 years, much of the proposed work is covered under the IEP's Endangered Species Act (ESA) Section 10 permit for take of listed salmon and sturgeon species. However, increased allowance for take of winter and spring-run Chinook, as well as green sturgeon, will be necessary. The CA Dept. of Water Resources (CDWR) research team is already in consultation with National Marine Fisheries Service (NMFS) to acquire this permission, and the IEP ESA coordinator plans to fold this work into the existing Section 10 permit for IEP. In addition, Sommer, Conrad, Reece, and additional field staff at DWR already possess Scientific Collecting Permits through Department of Fish & Game for work in the Yolo Bypass. These permits will need to be amended after federal permission for the proposed work is added to the IEP Section 10 permit.
4. Lead CEQA Agency:	N/A
5. Required Mitigation:	Yes ☐ No ☒

Section 4: Project Objectives

1. List task information:

Goal 1: *Endangered and other at-risk species and native biotic communities.*

Objective 1: Aid in the recovery and long-term persistence of Central Valley winter-, spring- and fall/late fall-run Chinook salmon ESUs, green sturgeon, Delta smelt, and Sacramento splittail.

The Yolo Bypass has known benefits for Chinook salmon and splittail rearing and survival (Sommer et al., 2001, 2003). Annually, ongoing monitoring work in the Bypass conducted by DWR documents use of the Bypass by Delta smelt and white sturgeon. Due to apparent benefits to native fish, the Bypass is a focus for restoration actions (BDCP, 2010). Restoration projects currently being considered are to improve passage for upstream-migrating fish such as salmon and sturgeon, and provide rearing habitat for native fishes. This project will directly address these priorities by using telemetry to document specific areas in the Bypass that present passage barriers to adult Chinook salmon and sturgeon under different hydrological conditions. We will also collect information on juvenile salmon residence time and survival in the Bypass, again using telemetry. Furthermore, we will synthesize an existing 10-yr dataset on salmon and growth in the Bypass in order to evaluate conditions that favor juvenile salmon rearing.

2. Additional objectives:

Goal 2: Ecological Processes.

Objective 6: Reestablish floodplain inundation and channel-floodplain connectivity to support the restoration and maintenance of functional natural floodplain habitats.

This project will provide information to determine the conditions necessary to restore floodplain habitat to support juvenile salmon. In general, the food web of the floodplain appears to be much more productive that the adjacent Sacramento River based on high levels of phytoplankton and invertebrate drift (Sommer *et al.,* 2001b, Schemel *et al.,* 2004; Sommer *et al.,* 2004b; Lehman *et al.,* 2008). However, specific thresholds (e.g., flow and inundation criteria) for enhanced lower trophic productivity have not yet been identified. In the proposed study, we will analyze an existing 12-year database (collected as part of an ongoing monitoring program in the Bypass conducted by biologists at CDWR) to identify these thresholds. In addition, the proposed work will collect new data on chlorophyll, and densities of zooplankton and drift invertebrates in summer and fall months, as these months are not represented in the current long-term dataset.

Goal 4: Habitats.

Objective 5: Manage the Yolo and Sutter Bypasses as major areas of seasonal shallow water habitat to enhance native and fish wildlife, consistent with CALFED Program objectives and solution principles.

The proposed interdisciplinary, multi-institution research program will directly address current issues that need to be addressed to accomplish informed management of the Yolo Bypass as a critical habitat for native fishes. For example, agency partners are in the process of developing design criteria to address barriers to adult salmon and sturgeon passage in the Bypass; yet the effect of barriers on migrating fishes under different hydrologic conditions, and behavior of fish in the vicinity of these barriers are unknown. Furthermore, more precise information on environmental factors favoring rearing habitat and survival for native fishes in the Yolo Bypass is needed in order to develop performance criteria for management. This project will collect new data and analyze existing data to fill this information gap. Finally, one of the components of this project will evaluate the use of sulfur isotopes as a chemical "fingerprint" of floodplain use on otoliths. If successful, this tool would allow broad-scale, retrospective analyses on all fish species of interest on use of the Yolo Bypass, as well as age and growth during floodplain residency. Such analyses would open the door for analysis of the role of the Bypass within the life history of native fishes, and could continue to be used in order to evaluate influence

	of the Bypass under different hydrologic conditions and changing management scenarios.
3. Source(s) of above information:	All above references are cited in Literature Cited section.

Section 5: Conflict of Interest

Primary Contact for Proposal: Ted Sommer, PhD (CDWR)
Primary Investigator: Ted Sommer, PhD
Co-Primary Investigators: Louise Conrad, PhD; Kevin Reece (CDWR); Mariah Meek, PhD (Genomic Variation Lab, UCD); Bernie May, PhD (GVL, UCDavis); Peter Klimley, PhD (Biotelemetry Lab, UC Davis)
Supporting Staff: Brett Harvey, Jared Frantzich (CDWR)
Subcontractor: None.

Provide the list of names and organizations of all individuals not listed in the proposal who helped with proposal development along with any comments.

Last Name	First Name	Organization	Role
Kirkland	Marianne	CA Dept. Water Resources	Consultation, review

Section 6: Project Tasks and Results Outline

FISHERIES EVALUATION OF FLOODPLAIN REARING AND MIGRATION IN THE YOLO BYPASS FLOODPLAIN

1. Detailed Project Description

Historically, the northern region of the Sacramento-San Joaquin River Delta (Delta) was a mosaic of floodplain, riverine, and tidal marsh habitats that supported exceptionally high biological productivity and influenced food webs of the entire estuary (Jassby and Cloern, 2000; Kimmerer 2004). In this way, North Delta is like floodplain-riverine systems worldwide that have a critical role in supporting food webs for entire aquatic ecosystems, but whose ecological functioning has been severely hampered by anthropogenic changes to the landscape (Thoms, 2003; Strayer and Findlay, 2010). Since the mid-1800s, the North Delta wetlands have suffered as a result of land reclamation for agriculture, levee construction, invasive species, flow regulation, and flood control (The Bay Institute 1998; CALFED 2001). Recognizing the importance of the North Delta, the Ecosystem Restoration Program (ERP) has committed significant resources to restoring key ecosystem landscapes and processes within the region (CALFED, 2001, 2004), particularly within the Yolo Bypass.

The Yolo Bypass is a 59,000-acre flood bypass structure that diverts floodwaters from the Sacramento River, Cache Creek and Putah Creek around the city of Sacramento and surrounding metropolitan areas (Fig. 1). The Bypass, which occupies the extensive historic floodplain of the lowermost Sacramento River, is managed for a mix of uses, including farming, riparian and managed wetland habitat, tidal marsh habitat, upland and grassland habitat, and flood control (Sommer *et al.,* 2001a, b; 2005). Given substantial evidence over nearly fifteen years for its benefits to native fishes during flooded periods (e.g. Sommer *et al.,* 1997; 2001a,b; 2002, 2003, 2004, 2005, 2008; Schemel *et al.,* 2004; Lehman *et al.,* 2006; Feyrer *et al.,* 2006), the Bypass has become the focus of interest in managing seasonally flooded habitat in the Delta. Hence, floodplain restoration has become a key part of the ERP Strategic Goals and Objectives based on the importance of Yolo Bypass to special status fishes such as Chinook salmon (*Oncorhynchus tshawytscha*), splittail (*Pogonichtys macrolepidotus*) and green sturgeon (*Acipenser medirostris*) (ERP Goal 1, Objective 1), key ecological processes (ERP Goal 2, Objective 6), and floodplain habitat (ERP Goal 4, Objective 5). Furthermore, the Yolo Bypass has been identified as a high restoration priority by the National Marine Fisheries Service (Biological Opinion on the Long-Term Central Valley Project and State Water Project Operation, Criteria, and Plan, 2009), the National Academy of Sciences independent review committee (2008), and by the Bay Delta Conservation Plan (BDCP). The restoration projects currently being considered are to: 1) improve passage for upstream-migrating fish such as salmon and sturgeon; 2) provide rearing habitat for native fishes; and 3) improve food web production in the North Delta. Yet, there are substantial data gaps necessary to fill in order to design and operate restoration plans, and develop performance criteria for evaluation of restoration actions. Our proposed studies will address these data gaps for each of the above restoration actions. In addition, we will synthesize over a decade of previously-collected data on Chinook salmon use of the Bypass and food web productivity to enhance our understanding of how the floodplain functions in these respects under current environmental conditions influence.

Adult Fish Migration: Adult fishes such as Chinook salmon, sturgeon, and splittail seasonally enter Yolo Bypass at its base, located north of Rio Vista (Harrell and Sommer 2003). While splittail will spawn on the floodplain, the consensus is that the area acts like a giant "fish trap" for salmon and sturgeon en route to spawning areas in on the upper Sacramento River because they are drawn into the floodplain's perennial channels following late fall or early winter flows with no exit from the Bypass at its upstream extent. Even modest flows (e.g. 1000 cfs) appear sufficient to draw fish into the floodplain. The Fremont Weir is located at the northern tip of the Bypass (Fig. 1), and is only connected to the Sacramento River during brief windows of high flows. Hence, the Yolo Bypass represents one of the most serious passage barriers to migratory fishes in the lower valley (NMFS 2008). However, beyond a general description of the timing and occurrence of large numbers of migrating Chinook salmon, sturgeon, splittail, striped bass (Harrell and Sommer 2003; BDCP 2010), remarkably little is known about what happens to these fishes once they enter Yolo Bypass. Some of the obvious questions that need to be answered to identify specific challenges to fish passage in the Bypass and eventually design appropriate fish passage facilities include the following:

- What is the residence time of adult migratory fishes (white sturgeon, Chinook salmon) in Yolo Bypass?
- Where do adult fish move to within the floodplain under different conditions?
- Are there specific areas of the floodplain where there is evidence of increased mortality, stress or holding behavior?

Juvenile Salmonid Rearing: Relative to adult migration, we know much more about juvenile Chinook salmon rearing in Yolo Bypass. Downstream-migrating juvenile salmon enter the Yolo Bypass from the Sacramento River and its tributaries during high flow events in winter and early spring (via flood flows over Fremont Weir). Once inside the Bypass, floodplain rearing results in enhanced growth as compared to juveniles residing in the adjacent Sacramento River (Sommer *et al.,* 2001a,b; Henery *et al.,* 2010), with potential survival benefits (Sommer *et al.,* 2001a). The floodplain feeding ecology of young Chinook salmon has also been documented (Sommer *et al.,* 2001b), and basic attributes of habitat area and residence time have been described (Sommer *et al.,* 2004, 2005). Nonetheless, we still have key uncertainties about salmon use of Yolo Bypass that need to be addressed for effective floodplain restoration:

- What environmental factors affect residence time, growth, and survival in Yolo Bypass?
- What is the general timing of emigration from the floodplain?
- What environmental factors affect emigration from Yolo Bypass?
- Which runs of Chinook salmon (fall, late-fall, spring, winter runs) use the floodplain?
- Are there specific areas of the floodplain where there is evidence of increased mortality?
- What portion of the salmon population currently rear in Yolo Bypass?

Food Web Dynamics: The improved growth rates and survival among salmon rearing in the Bypass appear to be linked to improved feeding success on the floodplain (Sommer *et al.,* 2001; Henery *et al.,* 2010). In general, the food web of the floodplain appears to be much more productive that the adjacent Sacramento River based on high levels of phytoplankton and invertebrate drift (Sommer *et al.,* 2001b, Schemel *et al.,* 2004; Sommer *et al.,* 2004b; Lehman *et al.,* 2008). Moreover, zooplankton growth appears to be relatively high (Mueller-Solger *et al.,* 2002). Among drift invertebrates, a floodplain chironomid comprises the majority of Yolo Bypass salmon diets (Sommer *et al.,* 2001b; Benigno and Sommer 2009). The degree to which the floodplain environment benefits these key food resources for salmon is at least partially linked with the quantity of flow and hydrologic residence times in the Bypass (Sommer *et al.,* 2004b), but specific thresholds (e.g., flow and inundation criteria) for enhanced lower trophic productivity have not yet been identified. While the extent to which productivity in the Bypass influences downstream areas (e.g., beyond the north Delta) is still not well understood (Sommer *et al.,* 2001a), modeling work by Jassby and Cloern (2000) suggests that floodplain inundation represents one of the most effective approaches to improving primary productivity in the estuary. As a consequence, there is interest in enhancing the productivity of the North Delta by improving connectivity between Yolo Bypass and Sacramento River (BDCP 2010). Current major information gaps for the design of these types of restoration projects include:

- What are the general communities of zooplankton, and drift invertebrate species in Yolo Bypass?
- How are zooplankton and drift species influenced by different environmental conditions?
- Are there specific thresholds for the magnitude and duration of inundation for enhanced lower trophic productivity?

This proposal seeks funding to address all of the questions listed above to develop baseline monitoring information and guidance for Yolo Bypass restoration projects to be considered by the ERP, BDCP, and the OCAP for federal and state water projects identified in the final NMFS Biological Opinion (NMFS, 2009). The project builds upon the past investment of the ERP in the Yolo Bypass and current and evolving institutional relationships between the University of California, Davis, California Departments of Water Resources (CDWR) and U.S. Bureau of Reclamation (USBR).

We have developed a multi-institution program that will use a combination of historical data analyses, new field work, and laboratory studies to address the major issues. This effort will involve government and university partners who will share expertise and resources. The assembled team includes some of the leading fisheries researchers in the region and has extensive experience working in Yolo Bypass. Moreover, the project will be conducted under the leadership of the Interagency Ecological Program (IEP), a consortium of state and federal agencies that have supported Yolo Bypass studies for the past 14 years. The proposed study has been designed to “leverage” the existing IEP monitoring program and facilities, resulting in numerous efficiencies.

Funding is requested for a two-year effort to collect and analyze the necessary data. The work schedule assumes a two-year study with a start date of September 2011 for the program. The tasks and questions to be addressed are identified for each program component, including the approach and important milestones.

2. Background and Conceptual Models

Physical Setting: The 59,000 acre Yolo Bypass (Fig. 1) is the primary floodplain of the Delta (Sommer *et al.,* 2001a, b), and presently floods in approximately 70 percent of years. The floodplain typically has a peak inundation period during high flows in January- March, but floods as early as October and as late as June. The primary input to the Yolo Bypass is through Fremont Weir in the north, which conveys floodwaters from the Sacramento and Feather rivers. During major storm events (i.e. > 175,000 cfs), additional water enters from the east via Sacramento Weir, adding flow from the American and Sacramento rivers. Flow also enters the Yolo Bypass from several small tributaries on its western margin including Knights Landing Ridge Cut, Cache Creek, Willow Slough Bypass and Putah Creek. During much of the winter, water suspended sediment levels in Yolo Bypass and Sacramento River result in highly turbid conditions (e.g. Secchi depths <0.25m). However, hydraulic residence times are typically longer in Yolo Bypass than Sacramento River, likely contributing to enhanced productivity levels (Sommer *et al.,* 2004b). Floodwaters recede from the northern and western portions of the Bypass along relatively even 0.09% west-east and 0.01% north-south elevation gradients into a perennial channel (“Toe Drain”, Fig. 1) on the eastern edge of the Bypass, then rejoin the Sacramento River near Rio Vista. The majority of the Yolo Bypass is presently managed for wildlife in a mosaic of riparian, wetland, upland and perennial pond habitats. Agriculture was a dominant land use during the past two decades, but has decreased in recent years because of habitat restoration activities.

Conceptual Models: The primary conceptual model for this project is the Delta Regional Ecosystem

Restoration Implementation Plan (DRERIP) floodplain conceptual model (Opperman 2008). The model is especially relevant because it was designed specifically to inform ecosystem restoration and public policy decisions within the Delta (e.g. ERP, BDCP and Delta Vision). Moreover, the model is based on data collected within the region, specifically Yolo Bypass. Key components of the DRERIP floodplain model include a food web model ("Model 3A"), which forms the basis for Task 5 in our study, and a species model for juvenile Chinook salmon ("Model 3C"), the basis for Tasks 1-4. Note that the DRERIP conceptual models explicitly acknowledge that there are substantial uncertainties about many of the linkages. The majority of these are issues of scale and boundary, explicitly identified in the "Model 1" component of the DRERIP floodplain model. For example, the basic conceptual model for salmon ("Model 3C") represents a fairly generalized description of the importance of floodplain to salmon, so our study has been designed to address the need for more detailed information on seasonal, genetic and spatial patterns. Hence, our study questions lay out some of the major unresolved issues for floodplain food web and juvenile Chinook salmon.

One factor not specifically addressed in the DRERIP floodplain conceptual model (Opperman 2008) is the issue of upstream fish passage. For the purposes of this study, our basic conceptual model is that increases in flow through Yolo Bypass trigger upstream migration of a suite of native fishes (white sturgeon, splittail, Sacramento pikeminnow) into the floodplain (Harrell and Sommer 2003; CDWR, unpublished data). These flows can be from either the Sacramento River or the smaller tributaries of Yolo Bypass (Fig. 1). All of these fishes are thought to migrate upstream into the base of Yolo Bypass via the Cache Slough Complex, located near Rio Vista (Fig. 1). Floodplain inundation is not required to draw fish into the Yolo Bypass, due to a perennial channel along the eastern edge of the floodplain. The conceptual model is slightly different for Chinook salmon, which do not appear to migrate in response to flow pulses (Harrell and Sommer 2003). Instead, their upstream migration appears to be seasonally mediated. However, For all species we propose that an unusually large percentage of fishes are drawn into the Cache Slough Complex and Yolo Bypass because of strong tidal currents in the Rio Vista area: recent studies by US Geological Survey (Jon Burau, unpublished data) demonstrate that at the junction between Cache Slough and Sacramento River, approximately *80 percent* of the tidal flow moves through Cache Slough Complex rather than the adjacent river channel. As a consequence, we suggest that there may be a strong tidal bias that leads migrating fish towards Yolo Bypass.

For all of the migratory fishes, the major concern in our conceptual model is that passage is impeded under most conditions. The four scenarios in our upstream migration model, along with their repercussions for passage, include the following:

1) No flow over Fremont Weir into Yolo Bypass
    a. Minor barriers (e.g. road crossings) in the perennial channel of Yolo Bypass ("Toe Drain") may require increased flows to be passable.
    b. Multiple minor tributaries such as Knight's Landing Ridge Cut cause fish to stray from the direct upstream route to Fremont Weir (the upper portion).
    c. Fremont Weir is impassable, so there is no upstream exit for any of the fish.
    d. Many fishes become trapped in dead-end channels, or must reverse their migration route and face major delays.
    e. This scenario often occurs in fall, when water temperatures are relatively high, resulting in thermal stress.
2) Modest inundation of Yolo Bypass via Fremont Weir (e.g. <50,000 cfs in Yolo Bypass)
    a. Small barriers become passable.
    b. Minor tributaries may still cause substantial straying, resulting in entrapment in some locations.
    c. No passage out of Yolo Bypass except perhaps salmonids, which may be able to jump over the head of Fremont Weir.
3) Moderate inundation of Yolo Bypass via Fremont Weir (e.g. 50,000-100,000 cfs)
    a. No passage out of Yolo Bypass except salmonids, which should be able to jump over the head of Fremont Weir.

4) Heavy inundation of Yolo Bypass via Fremont Weir (e.g. 100,000-500,000 cfs)
   a. If they can swim against the fast currents, many of the migratory fishes may be able to pass Fremont Weir at these extreme flows.

The bottom line for the upstream migration conceptual model is that the floodplain is largely impassible most of the time: the typical condition of Yolo Bypass is scenario #1. Even in years where the Bypass floods, flow over the Fremont Weir is often only transient, occurring for only days at a time; thus, scenarios #2 – 4 that allow for some passage represent less than ten percent of the time during migration windows. We hypothesize that the unique hydrodynamics of the floodplain create a giant "fish trap," perhaps the most serious upstream fish passage problem in the lower Sacramento Valley. However, we acknowledge that there are substantial uncertainties about what happens to fish during upstream migration. Our telemetry element is therefore designed to develop detailed information (e.g. spatial and temporal patterns) to test many aspects of the conceptual model.

3. Approach and Scope of Work

The basic approach includes five basic tasks using a multi-agency, interdisciplinary effort: 1) adult salmon and sturgeon and juvenile salmon telemetry; 2) salmon genetics and exposure to thermal stress; 3) analyses of historical salmon data; 4) salmon otolith studies; and 5) analysis of historical food web data. The proposed new work would be conducted in tandem with the long-term monitoring effort in Yolo Bypass, which currently provides data on fish (rotary screw trap, fyke trap, beach seining, larval sampling), food web (chlorophyll a, zooplankton, drift) and a suite of environmental variables (e.g. water temperature, electrical conductivity, Secchi depth). This long-term monitoring effort is funded separately from the ERP proposal through the IEP. However, the proposed work requires the basic monitoring program to be expanded in order to provide samples for each of the project components; thus, additional funds to those provided by IEP are requested. We propose to coordinate the ERP and long-term monitoring projects through a new IEP Project Work Team. The Project Work Team meetings, which are open to stakeholders and other agencies, will provide a good opportunity for guidance, information transfer, and regular updates for the effort.

Samples to be analyzed and potential fish "take" for each major task of the study are summarized in Table 1. Note that the study is not contingent on a flood year in order to be successful. The adult telemetry, thermal stress and genetics tasks (Tasks 1, 2) should be successful regardless of hydrology because migration occurs in all years via the floodplain's perennial channel network. Juvenile telemetry (Task 1) would be most interesting in a flood year, but tracking of hatchery-grown fishes would still yield data on floodplain residence time and survival rates through the Bypass under lower flow conditions. The juvenile genetics and isotopic work (Tasks 2 and 4) would benefit from additional collection of wild juvenile salmon entering the Bypass via the Fremont Weir; however, we have substantial archives from earlier years that could be used in the unlikely event that no additional young salmon are collected. Analyses of historical data (Tasks 3 and 5) are not contingent on hydrology. Finally, the supplemental food web sampling (Task 5) is focused during non-flood seasons.

Task 1. Telemetry

Task 1.1 Adult Telemetry Study
Project Lead: Peter Klimley, UC Davis
Field Assistance: Kevin Reece, CDWR and field staff

Study Questions:
- What is the residence time of adult migratory fishes (white sturgeon, Chinook salmon) in Yolo Bypass?
- Where do adult fish move to within the floodplain under different conditions?
- Are there specific areas of the floodplain where there is evidence of increased mortality or holding behavior?
- Do migratory fish move into areas of maximum flow and use this as a cue to migrate upriver?

Proposed Approach: Coded ultrasonic beacons will be surgically implanted in 25 adult Chinook salmon and white sturgeon captured in the fyke net operated by CDWR biologists as part of the ongoing monitoring program for the Yolo Bypass (Fig. 1). Migratory path, residence time, and habitat selection will be recorded for each species with an array of tag-detecting monitors deployed throughout the floodplain over a period of two years. Monitors (VR-2W, 69 kHz, Vemco Ltd.) capable of detecting adult beacons (V13 or V16, 5 – 10 year lifespan), will be strategically placed at entry and exit points from the Bypass to determine residence time and in a single cross-floodplain array to determine the east-west range of movement under flood conditions. Specifically, monitors will be placed at the southern tip of the Toe Drain to determine whether adults exit the Bypass after encountering obstacles to passage upstream, and at the Fremont Weir to determine behavior at the northern extent of passage through the bypass (in most years for salmon, and in all but the most extreme flood years for sturgeon). Additional monitors will be placed on alternating abutments to the I-80 highway causeway crossing the Yolo Bypass, for a total of six monitors in this cross-sectional array. Possible areas for holding behavior are at tributary inputs to the Toe Drain because they present attracting flows for upstream movement, but after short distances present barriers to migration. Thus, monitors will be placed at the mouth of Knight's Landing Ridge Cut, Willow Slough, Sacramento Bypass, and at Lisbon weir, which is located near the mouth of Putah Creek. Additional monitors will be placed in Putah Creek and Knight's Landing Ridge Cut at the western edge of their entrance to the Bypass where barriers to passage are present (Fig. 1). Installation of these 18 monitors in the Yolo Bypass will expand the extent of an existing array of nearly 300 monitors deployed within the mainstem of the Sacramento River, Delta, and San Francisco Bay. Thus, adult fishes tagged within the Yolo Bypass will be detectable in the Bay-Delta should they exit the Bypass, and similarly, any fish tagged with V13 or V16 tags for separate telemetry studies will be detected should they enter the Bypass. These acoustic tags have been used previously for tracking green sturgeon both marine environments (Lindley *et al.*, 2008) and locally in the Sacramento River system (Heublein *et al.,* 2009).

Task 1.2. Juvenile Telemetry Study
Project Lead: Peter Klimley, UC Davis
Field Assistance: Kevin Reece and Zoltan Matica, CDWR and field staff

Study Questions:

- What is the survival of juvenile salmon in the floodplain as compared to in the Sacramento River?
- What is the residence time of juvenile salmon in the floodplain as compared to in the Sacramento River?
- Are there specific areas of the floodplain where there is evidence of increased mortality?

Proposed Approach: In previous years, coded wire tags have been placed on hatchery raised, late-fall run Chinook smolts to provide baseline information on their movements, residence time, and survival in the floodplain. However, the knowledge that this approach provides, though important, is rudimentary because tag recovery is lethal, precluding detection of tagged fish further downstream during outmigration. The development of coded ultrasonic beacons, implanted within the peritoneum of a fish, has enabled the tracking of a single salmon smolt as it migrates down the mainstem of the river or as it passes an array of monitors placed across the floodplain. Ultrasonic telemetry will be used to determine residence time and survival of juvenile Chinook salmon as they migrate through the Bypass, and track their specific migration route through floodplain. This technology has proven to be an effective approach to examine juvenile salmon movements through the estuary (Perry *et al.*, 2010).

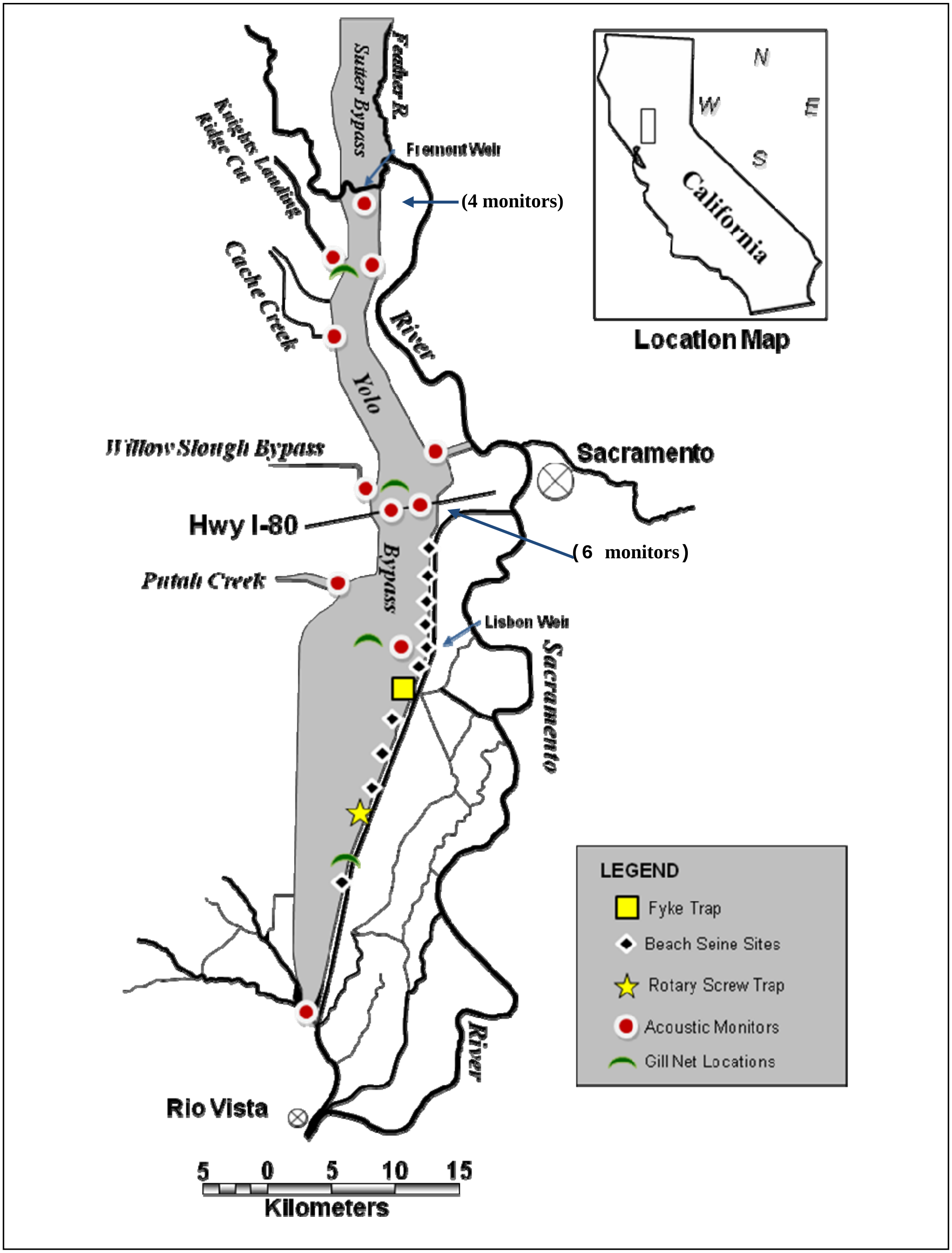
We will tag late-fall run of Chinook smolts because our release into the Yolo Bypass will be matched by a parallel release of 125 similar smolts into the mainstem of the Sacramento River, to be carried out by the US Army Corps of Engineers (USACE) near during Years1 and 2 of our study. These fish will carry either V5 or V6 coded beacons, detectable by the VR-02w with a higher frequency resonance of 180 kHz used in the bypass. USACE is open to the idea of placing eight of their monitors currently deployed in Georgiana Slough within the mainstem of the Sacramento River at the entrance and exit to the Cache Slough Complex and Bypass, and at intervals between these locations. This approach will permit us to compare the residence time and survival of smolts in the mainstem versus the floodplain. The late-fall run smolts will be obtained from the Coleman National Fish Hatchery (USFWS), the same source of fish used for extensive experiments that were carried out to assess the burden of slightly larger V7 coded beacons on the swimming and growth rates as well as the rate of beacon shedding (Ammann *et al.,* 2010). Although there was a slight difference between control, sham-operated, and tag-implanted fish (tag weight burden at 8% of the fish body mass) on swimming performance, there was no shedding of the V7 tags implanted within the fish. Our tags will be considerably smaller than the tags used in those tests, and the tag burden will likely be equal to or less than 5% of the body mass of the fish. The probability of mortality was less and growth higher for tag-implanted Chinook smolts compared with than control fish at a burden of 5.1% for slightly smaller Chinook than those we plan to use for the proposed study (Brown *et al.,* 2011).

We will release 50 late fall-run smolts at the upstream extent of the Yolo Bypass during any flood event in Years 1 and 2, and their movements will be monitored throughout the floodplain by an array of tag-detecting monitors deployed during the rainy season. The monitors (VR-02, 180 kHz) that will detect the smaller V5 and V6 beacons will be attached to the same moorings that hold the monitor that detect the larger V13 and V16 beacons for the adult telemetry work (Fig. 1). The residence times and rates of survival in the Yolo Bypass will be determined from the entry and departure times obtained from monitors situated at the entry and departure points to the floodplain. They will be compared to the residence times and rates of survival of the smolts tagged and released in the mainstem by USACE that do not enter the Bypass. Finally, we will determine whether there are specific regions of the floodplain where there is evidence of increased mortality. The six monitors either secured to the I-80 overpass will be placed at sites with different substrates (sand versus brush) and different potential depths (shallow versus channel) to ascertain whether the late-fall run smolts favor one microhabitat over another during flooding events.

Table 2. Annual sample sizes for each species for each task. Numbers of fish to be sampled for non-lethal take are indicated, with numbers for lethal take indicated in parentheses.

	Yolo Bypass Screw Trap	Seine	Fyke	Gill net	Sacramento Trawl	Knights Landing Screw Trap (Sac. R.)	Sacramento River (anglers)	Hatchery	Sample Archives
Telemetry									
Chinook Juveniles								100	
Chinook Adults			25						
White Sturgeon			25						
Genetics									
Chinook Juveniles	400				400				137
Chinook Adults			50						
Stress									
Chinook Adults			50				50		
Isotope									
Chinook Juveniles	(110)					(110)			

Figure 1. Map of the Yolo Bypass and the surrounding region, with all locations for all sampling and monitoring locations indicated.



Task 2: Chinook salmon run identification and investigation of thermal stress

Project Leads: Mariah Meek, Bernie May, UC Davis
Project Collaborator: Josh Israel, Bureau of Reclamation
Field Assistance: Kevin Reece, CDWR and field staff

Task 2.1: Genetic Analyses:
Study Questions:

- What runs of adult and juvenile salmonids use the Yolo Bypass floodplain?
- Are different runs of juvenile salmonids found in the Yolo Bypass as compared to those migrating through in-river habitat?

Proposed Approach: To date, no study has looked at the proportional use of the Yolo Bypass by the different runs (spring, winter, and fall) of Chinook salmon. Proper identification of salmonids using the Yolo Bypass is necessary to achieve the first ERP goal statement of "recovery of at-risk native species dependent on the Delta." Genetic tools are invaluable to confidently determine run type of Chinook salmon, as size-at-time of capture is an unreliable predictor of run in the Sacramento/San Joaquin system (NMFS 2008). In this task, we will non-lethally collect fin tissue samples from juveniles and adults sampled during this study in order to evaluate the use of the Yolo Bypass by the different runs of Chinook salmon, as well as analyze archived samples collected previously by CDWR.

Juvenile sampling—Fin tissue samples from juvenile Chinook salmon will be collected through ongoing sampling efforts in the Yolo bypass conducted by CDWR(8 beach seine locations throughout the Bypass and the rotary screw trap, Fig. 1)—as well as at one site in the mainstem Sacramento River. Fin tissue samples for genetic analysis will also be collected from any Chinook sampled for the isotope study (Task 4). Juvenile salmonids will be collected in the mainstem Sacramento River through US Fish & Wildlife Service's ongoing mid-water and Kodiak trawl sampling at River Mile 55, downstream of the last mainstem river entrance into the Yolo Bypass (the Sacramento Weir). This will allow a comparison of the juveniles using in-river habitat for rearing and migration with those utilizing the Yolo Bypass. It is possible we will find that some runs use the Yolo Bypass proportionally more, while others rely more heavily on in-river habitat, regardless of available passage into the Bypass. Additionally, we will determine the run type of 137 archived wild juvenile Chinook salmon collected in the Yolo Bypass between 1998 and 2002. These samples will provide an informative comparison of present day use of the bypass with historical use.

Adult sampling-- Adult fin tissue samples will be collected from adults captured in the CDWR fyke net sampling as well as directed gill-netting efforts for this project during the fall and winter (Fig 1). Fin tissue will be collected from all adult Chinook sampled in the fyke and gill nets. This information will be invaluable for interpreting the results of telemetry studies, as it is necessary to understand the run each individual belongs to properly interpret research findings. Collectively, these analyses will be very beneficial for understanding Chinook salmon use of the Yolo Bypass.

Sampling effort--The annual unpredictability of salmon populations and water conditions (flood versus drought) in the Central Valley make it uncertain when juveniles will be present in the system to sample each year. However, it will be beneficial to confidently identify all the fish that are collected, no matter how small the numbers, as it will tell us a great deal about the use of the Bypass in wet or dry water years. During flood years, however, it is possible that as many as several thousand juvenile Chinook will be sampled in the rotary screw trap alone over the course of the winter and spring seasons. Given this variability, each year we will sample up to 400 juveniles from the Yolo Bypass in order to fully characterize the use of the Yolo Bypass by the different runs of juvenile Chinook salmon. If catch numbers allow, we will spread this sampling across the collection sites (screw trap and beach seine locations, Fig. 1) and over the course of the season in the Yolo Bypass. We will sample up to 400 juveniles at the USFWS trawl site to compare run composition in the main stem of the Sacramento River with the Yolo Bypass composition. Samples at the mainstem site will be temporally paired with the Yolo Bypass sampling, to the best of our ability.

This will allow us to compare the diversity of salmonids found in the mainstem Sacramento River with those found in the Yolo Bypass. We will genotype up to 50 adults sampled in the Bypass through the fyke and gill net sampling, including those caught for the telemetry study.

Sample processing--All samples will be placed in 95% ethanol and transported back to the University of California-Davis Genomic Variation Lab (GVL) for processing. We will determine the run type of all samples collected using a combined panel of 96 Single Nucleotide Polymorphisms (SNPs) and microsatellite markers. These markers have been successfully employed to identify Central Valley Chinook salmon runs (Anthony Clemento--NMFS, unpublished data, Garza *et al.,* 2008). The GVL is currently developing a baseline genetic database of Central Valley salmonids using these markers. This database will be complete and available for use during this proposed study. This database will provide the necessary background information required to confidently assign individuals to their appropriate run and potentially their natal stream. The results of this study will be informative for putting the salmonids found in the Bypass in the context of the greater Central Valley Chinook salmon populations. Additionally, it will be used to evaluate the effectiveness of the "Fisher criteria" currently used for operations in the OCAP Biological Opinion (NMFS 2008), as described in Task 3.

<u>Task 2.2: Thermal stress:</u>

Study Questions:

- Is there evidence of thermal stress in adult salmonids attempting to migrate to spawning areas through the Yolo Bypass?
- How does the degree of thermal stress compare between adult Chinook salmon migrating via the mainstem of the Sacramento River and those attempting passage through the Yolo Bypass?

Proposed Approach: Thermal stress is known to be detrimental to all life history stages of salmonids (Sullivan *et al.,* 2000, Brett 1995). Adult Chinook found in the Yolo Bypass may be undergoing severe temperature stress as water temperatures in the Bypass can rise above 20˚ Celsius during the period when adult fall-run Chinook enter the Bypass. Temperature data loggers in the Sacramento mainstem and Yolo Bypass show that temperatures in the Yolo Bypass in September are generally higher than in the mainstem Sacramento River. In 2008 the maximum daily temperature was higher in the Yolo Bypass 28 out of 30 days in September, the daily maximum being on average 1.56˚ Celsius higher. In 2009 the temperature differences were stronger, with maximum daily temperatures being higher in the Bypass for all days in September, the daily maximum being on average 2.2˚ Celsius higher (K. Reece, CDWR, unpublished data). At the mainstem site, there were 4 days in October 2008 and 0 in October 2009 that reached above 20˚ Celsius in the mainstem, while there were 8 and 3 days, respectively, in the Yolo Bypass that reached above 20˚ Celsius. Due to these differences, we hypothesize that salmon found in the Bypass in September and October will show significantly higher signs of thermal stress compared to those found in the mainstem Sacramento River. Moreover, this thermal stress is exacerbated because of inadequate adult fish passage through the floodplain (see Conceptual Model).

To evaluate this hypothesis, each year we will sample up to 50 adults caught in the Yolo Bypass, including those in the telemetry component, for a molecular analysis of thermal stress. To sample adults for thermal stress, we will collect a small amount of gill tissue from adults immediately upon capture, place the tissue in Ambion RNA*later* Solution for preservation, and transport it back to the GVL for analyses. This non-lethal gill tissue collection method has been successfully used in concert with telemetry studies to investigate gene expression and spawning success in other migrating salmonids (e.g. Miller et al 2011). To determine if Chinook salmon experience different levels of thermal stress in the Yolo Bypass as compared to those migrating through the main-stem Sacramento, we will also sample 50 adults per year in the mainstem Sacramento River. This will be done by joining the DFG sports fishing creel survey once a week during the same period we are sampling adult fish on the Yolo Bypass. This will provide the greatest opportunity to sample adult Chinook salmon in the Sacramento River.

All gill tissue samples will be processed and analyzed at the GVL. The GVL is currently examining gene expression profiles for Chinook salmon under different temperature stress regimes using laboratory studies. We will use information gained from controlled laboratory conditions (i.e. candidate genes) to test adults found in the

Bypass for signs of thermal stress. We will conduct quantitative PCR (qPCR) for genes implicated in response to thermal stress to evaluate each fish's stress level. The appropriate negative and positive controls will be included for all stages of the proposed expression analyses. We will also determine the relative expression of heat shock protein (hsp) in each fish sampled. Heat shock proteins are synthesized in response to thermal stress and can be an excellent indicator of exposure to elevated temperatures in fishes (De Maio 1999, Werner *et al.,* 2005, Fangue *et al.,* 2006). We will analyze each gill tissue sample for hsp70. This has been shown to be an effective way to measure thermal stress in salmonids in the field (Werner et al 2005, Fader *et al.,* 1994, Washburn *et al.,* 2002). One concern with studying the expression of a gene synthesized in response to stress is that in-field handling of individuals will induce increased synthesis of stress proteins and complicate the interpretation of results. Heat shock protein 70 has been shown to be minimally synthesized in response to handling stress in other salmonids, so it will be an effective indicator in our study (Washburn *et al.,* 2002). Another concern is that heat shock proteins have also been shown to be synthesized in response to pathogens and contaminants (Forsyth *et al.,* 1997, Bierkens 2000). However, this response is often minimal compared to the induction from thermal stress (Bierkens 2000). Regardless, if we find a difference in hsp70 induction between adults found in Yolo Bypass and the Sacramento River, it will be an important indicator that adults in the Yolo Bypass are experiencing stressful conditions. The pairing of hsp70 expression analysis with the candidate gene expression study will supply powerful verification that any elevated levels of hsp70 observed are due to thermal stress in the fish sampled. This combined approach will provide a comprehensive, quantifiable, and highly sensitive measure of expression level in response to heat stress in the sampled adult salmon.

Task 3. Historical Salmon Data Analyses

Project Leads: Kevin Reece, Ted Sommer, Louise Conrad, CDWR
Study Questions:

- What environmental factors affect residence time, growth, and survival in Yolo Bypass?
- What is the general timing of emigration from the floodplain?
- What environmental factors affect emigration from Yolo Bypass?
- What size categories (runs) of salmon use the floodplain?

Proposed Approach: CDWR (under the guidance of IEP) has conducted monitoring of the Yolo Bypass since 1997. Much of the emphasis of this monitoring has been juvenile Chinook salmon. Important issues such as growth and feeding ecology have been examined (Sommer *et al.,* 2001a, b; 2005; Henery *et al.,* 2010), but the above questions remain and are highly relevant to floodplain restoration. Fortunately, CDWR has developed a substantial database that we believe can be used to address some of these issues.

Data analyses will focus on two components of CDWR's Yolo Bypass fisheries monitoring program. First, catch of wild juvenile salmonids has been measured each winter and spring since 1998 using a rotary screw trap near the base of the floodplain (Sommer *et al.,* 2005; Fig. 1). Second, groups of approximately 50,000-100,000 coded-wire tagged (CWT) juvenile hatchery fish were released into the top of Yolo Bypass during February of most years since 1998 (Sommer *et al.,* 2001b, 2005) in order to determine residence time, survival, and growth rates. These marked fish were subsequently recovered by the Yolo Bypass rotary screw trap, and by the ocean fishery until 2007, when the fishery was closed because of low stocks. During the same period, environmental data were collected including flow, duration of flooding, photoperiod, and temperature.

The environmental variables affecting residence time, emigration time, growth, and survival will be addressed by analyzing the dependent (fisheries) and independent (environmental, population data) variables (Table 2). The variables include both inter-annual and intra-annual categories that will help us address different study questions. Least squares regression (e.g., Grimaldo *et al.,* 2009) or more complex models (e.g., Sykes *et al.,* 2009) would be used to identify the major relationships.

Table 2. Summary of Statistical Analyses. *CWT fish shown in italics;* their survival data is available through 2005 releases. The survival ratio is calculated based on the difference in ocean recaptures for parallel release groups in Yolo Bypass and Sacramento River. Their growth would be calculated as the difference between size at release and recapture in the screw trap. Wild fish analyses would be restricted to fall-run sized fish (no smolts) and only for flood years only (98, 99, 00, 02, 03, 04, 05, 06, and 10). Apparent growth rate would be calculated on daily sizes of fish (Sommer *et al.,* 2001a).

Inter-annual Variables

Dependent variables	Independent variables
Residence Time	Flow (mean)
Survival ratio	Duration of flooding (days)
Growth	Photoperiod (mean)
Apparent growth rate	Temperature (mean)
Total catch/day	Temperature (ATU)
Timing of emigration (median)	Escapement (fall + spring run adults)

Intra-annual Variables

Dependent variables	Independent variables
Catch/day	Flow (daily)
Presence/Absence	Temperature (daily)
	Temperature (daily ATU)
	Photoperiod (daily)

The question of emigration timing will be addressed using graphical and tabular summaries of the rotary screw trap data. For the size classes of fish will be divided into categories using the "Fisher criteria" currently used for operations in the OCAP Biological Opinion (NMFS 2008). The previously described genetic work (Task 2) will be used to help validate the effectiveness of these criteria.

Task 4. Salmon Isotope Studies

Project Leads: Rachel Barnett-Johnson, USBR
Field Assistance: Kevin Reece, CDWR and field staff

Study Questions:

- What is the temporal and spatial variation in sulfur isotopic composition of invertebrate prey on the Yolo Bypass floodplain?

- Does the Yolo Bypass food web have a unique sulfur isotopic signature from the mainstem, hatcheries, and tributaries?
- Does the sulfur isotopic signature of the floodplain get incorporated into salmon otoliths?
- Can sulfur isotopes in otoliths be used to quantify residence time on the Bypass?

Proposed Approach: While the benefits of floodplain rearing for salmonids have been shown (Sommer *et al.,*, 2001b, 2005, Henery *et al.,*, 2010), the population-level benefit in terms of increased survival during downstream migration and adult return rates are still undocumented. Physical tags and/or telemetry can be used to estimate survival of juveniles on the Yolo Bypass. However, the proportion of juveniles or adults in the population that reared in the Bypass cannot be quantified with these methods. To assess the population-level "fingerprint" of floodplain juvenile rearing for wild fish, it is necessary to develop a tool that will allow retrospective analysis of rearing history for both outmigrating smolts and returning adults. Recent evidence shows a unique sulfur isotopic composition of water sulfate in the Yolo Bypass. Since sulfur isotopes can be measured in fish on a daily basis in otoliths, a promising approach is to investigate sulfur isotopes in otoliths as a floodplain marker to determine use, growth, and residence time in the Bypass. This task will assess the feasibility of this approach.

The sulfate in the water in the Yolo Bypass has been shown to have a uniquely light sulfur isotopic composition ($^{34}S/^{32}S$) reflective of a difference in the base of the food web (Carol Kendall, USGS, Bay-Delta Science Conference, 2010). Like carbon isotopes, sulfur isotope ratios do not change as they move up the food web (Michener and Schell 1994; Hobson *et al.,* 2010). Thus, differences at the energy sources at the base of the food web propagate up the trophic hierarchy from the water, to invertebrate prey, and into the muscle, and ear bone (otolith) protein of fishes feeding on that food web (Weber *et al.,* 2002; Barnett-Johnson *et al.,* 2010; Godbout *et al.,* 2010). If the food web signature of the Yolo Bypass is unique, temporally, and spatially robust, then it could be used as a quantitative tool to assess and reconstruct floodplain habitat use and residence time for different native fish species (e.g., salmon, steelhead, sturgeon, splittail). For example, the sulfur isotopic composition of salmon otoliths could be measured from juveniles collected at a downstream sampling location (e.g., Chipps Island) to determine the proportion of fish that used the floodplain habitat. Similarly, adult Chinook salmon otoliths from the ocean fishery or from spawning populations could be sampled to reconstruct whether these adult survivors used the floodplain as juveniles. Thus, this tool could be used to quantify a population-level benefit of the floodplain.

Fall and spring-run juvenile Chinook salmon will be collected from the rotary screw traps operated in the Yolo Bypass and on the mainstem of Sacramento River (Knights Landing) during floodplain inundation in a temporally stratified design (max 5 days per week from Jan-June; N≈220; Table 1). Stomach contents and otoliths will be analyzed for sulfur isotopic composition as per established techniques (Goodbout *et al.,* 2010; Weber *et al.,* 2001; Barnett-Johnson *et al.,* 2010). The sulfur isotopic composition of prey items in the stomachs of juvenile salmon collected on the floodplain will provide the maximum variation in the Bypass isotopic signature (capturing variation in $^{34}S/^{32}S$ over space, time, and individual residence time). This will allow us to determine whether sulfur isotopes are a robust marker at the appropriate scales to characterize floodplain habitat use by fish. Comparison of $^{34}S/^{32}S$ in prey items in the stomachs between fish collected on the Bypass and at Knights Landing, will allow us to estimate the difference in $^{34}S/^{32}S$ in food webs between the floodplain and several upstream tributaries/mainstem. In addition, $^{34}S/^{32}S$ values of tributary waters previously measured by USGS and in the literature will be used as a reference to assess the uniqueness of the Yolo Bypass signature relative to other rearing habitats in the Sacramento-San Joaquin basin (Carol Kendall, USGS, Weber *et al.,* 2002).

The sulfur isotopic composition for a subset of otoliths will be analyzed to determine if the isotopic signature of the floodplain (e.g., prey) gets incorporated into the otolith. A probe-based mass spectrometer is used to measure $^{34}S/^{32}S$ in the otolith corresponding to daily growth in the fish. Therefore, for individuals with a floodplain $^{34}S/^{32}S$ value on the edge of the otolith (most recent growth), additional sampling points will be analyzed to determine how many days that the individual as spent rearing on the floodplain. From these data, we can estimate the size the fish entered the floodplain.

Task 5. Food Web Studies

Project Lead: Brett Harvey, Kevin Reece, Louise Conrad, Ted Sommer, CDWR

Study Questions:

- What are the general patterns in zooplankton, and drift invertebrate species in Yolo Bypass?
- How are zooplankton and drift species affected by different environmental conditions?
- Can specific thresholds be identified for flow, magnitude, and duration of inundation for enhanced lower trophic productivity?

CDWR has conducted food web studies in Yolo Bypass since 1998. The major components of the program include chlorophyll a, zooplankton, and drift sampling. While some of the data have been analyzed (Schemel *et al.,* 2003; Sommer *et al.,* 2004b; Benigno and Sommer 2008), most of the information has yet to be examined in a detailed way. Moreover, the sampling was done only during winter and spring, so there is not information about food web dynamics during other seasons. This information is particularly important to understand the possible contribution of ERP improvements to the estuarine food web during other months.

Similar to the historical studies for juvenile salmon (Task 3), Task 5 will conduct statistical analyses on the archival information for plankton and invertebrates to describe community composition and relationships with environmental variables. Simple graphical presentations will be used to summarize the data from multiple years. Multivariate analyses (e.g. nonmetric multidimensional scaling) will be used to evaluate the relationships between the environmental variables (examples of independent variables shown in Table 2) and food web components. Depending on the outcome of these analyses, a regression approach may be used to evaluate whether there are specific flow thresholds that generate major increases in food web production—this issue is currently of major interest for the design of restoration strategies for Yolo Bypass.

As noted above, the current IEP monitoring only conducts food web sampling during winter and spring. Because of the information gap for summer and fall months, this ERP task will provide supplemental information for July-December for the two study years at the same locations. The data will be analyzed using some of the approaches described above for the archival data.

4. Deliverables

The monitoring and assessment program developed by this multi-institutional collaboration will yield a range of products and deliverables. The team of principal investigators is responsible for the timely completion of all deliverables and serves as the principal contact for ERP staff and local stakeholder groups.

Reports. The team will coordinate and prepare quarterly and annual reports for the ERP. Quarterly reports will include regular activities of all program elements and component programs. Annual reports will include a summary of data gathered in the component program.

Publications and Conferences. The goal of this project is to generate regular peer-reviewed publications of results and to share of information and ideas at conferences. Each component's program will publish two or more analyses in peer-reviewed journals. One or more members of each program will also present their results annually at either the State of the Estuary or the Bay-Delta Science conference. In addition, each program component will present their results at one statewide and one national conference annually.

5. Feasibility

The project team includes staff involved in Yolo Bypass monitoring of fishes and lower trophic organisms since the project began in 1998, and draws on the expertise of additional investigators for telemetry, genetics, and otolith microchemistry study components. Given that the Aquatic Ecology group at CDWR has already published numerous articles on the Yolo Bypass, these team members are uniquely qualified to analyze and interpret the historical floodplain data (Tasks 3 and 5).

The proposed acoustic tags for tracking adult fishes in the Bypass (Task 1.1) are already used successfully by Dr. Klimley in the San Francisco Estuary, with over 300 compatible monitors located in the Sacramento River, Delta, and the San Francisco Bay. Creating arrays of the same monitors would not only afford telemetric studies in the Bypass, but also allow broad, regional-scale tracking of adult fishes tagged in the Bypass. The CDWR Aquatic Ecology group has operated the fyke trap in the Yolo Bypass Toe Drain since 1998 and reliably captures enough white sturgeon to cover the proposed sample sizes for telemetry work, even in dry years. With comprehensive knowledge of the Yolo Bypass hydrology, CDWR team members are also well-qualified to perform strategic gill-netting in order augment sample sizes of adult Chinook salmon captured in the fyke net. Use of the fyke net as a sampling method for adult fishes is already permitted under the IEP Section 10 permit for incidental take of listed species. Additionally, CDWR team members are already in contact with National Marine Fisheries Service to request take ESA Section 10, incidental permission for gill-netting activities. Initial feedback from NMFS has been used to guide to study design to minimize take and maximize study benefits. For the juvenile salmon telemetry work (Task 1.2), larger tags than the ones proposed for this study have already been tested for their effects on swimming performance and growth in Chinook salmon, thus we have a high level of confidence in the use of this technology for the juvenile telemetry.

Dr. May's laboratory (UCD) has a long history of successful genetic studies in California fishes in general and salmonids specifically. They are already genotyping California salmonids at SNPs, microsatellites, and other molecular markers; thus, the methodology for the salmon genetics work (Task 2.1) is already tested. They are a highly prolific molecular lab with a long track record of project completion and success. In addition, this laboratory is already conducting the assay for gene expression under thermal stress in juvenile, hatchery-reared Chinook salmon; thus, the methodology for this component (Task 2.2) is already tested.

Dr. Barnett-Johnson is an expert in salmonid otolith chemistry and has already completed several projects and articles on the topic, making her an ideal choice for investigating the Yolo Bypass otolith marker (Task 4). Study design, implementation, and decisions for each project component will be managed by the appropriate Principal Investigator, with general guidance on all components from CDWR.

6. Relevance to the CALFED ERP

Relevance to CALFED ERP. Floodplain restoration has become a key part of the ERP Strategic Goals and Objectives, based on the importance of Yolo Bypass to special status fishes such as Chinook salmon (ERP Goal 1, Objective 1), key ecological processes (ERP Goal 2, Objective 6), and floodplain habitat (ERP Goal 4, Objective 5). This project will address both Priority 1 (restoration projects to enhance aquatic habitat in the Delta) and Priority 2 (research to test hypotheses regarding conservation measures) listed in the PSP. Based on previous research (Sommer *et al.,* 2004b, 2005), the Yolo Bypass presents an excellent opportunity for floodplain restoration within the Delta. The research will inform restoration actions in the Yolo Bypass by highlighting conditions that support key food resources and habitat characteristics for juvenile salmonids. Understanding current movement patterns of adult salmon and sturgeon in the Bypass and impediments to their passage to spawning areas in the Sacramento River or tributary streams is another critical component of restoring habitat for native fish in the Bypass.

Relevance to CALFED Issues Outside this PSP. Floodplain restoration and improved passage of adult salmon and sturgeon through the Yolo Bypass are key restoration actions specified within the NMFS Biological Opinion and RPA for salmon, steelhead, and green sturgeon. The National Research Council's Committee on Sustainable Water and Environmental Management in the California Bay-Delta has reviewed these actions, supports them as scientifically justifiable, and recommends them for early implementation (NAS, 2010). Evaluation of the success of future restoration projects such as increased area or duration of inundation, or modifications to structures that impede passage, will require baseline data on pre-project conditions. The proposed work will build on an existing fisheries and lower trophic organism monitoring program operated by CDWR by synthesizing an existing dataset and collecting more detailed data on habitat use by key native species as well as challenges to adult passage through the Bypass.

7. Expected quantitative results

This is a research project and will yield scientific papers and valuable tools and databases to be used for future resource management needs (see sections for 'Deliverables' and 'Other products and results'). However, the products are not quantifiable in the specific manner identified in Appendix E of the PSP (e.g. number of trees planted, diversions screened, or acres of habitat described).

8. Other products and results

In addition to the deliverables described above, funding for Tasks 1.1 and 1.2 will result in creation of an array of 18 telemetry monitors appropriate for tracking acoustically tagged fish in both juvenile and adult life stages. The equipment for these arrays will build on existing arrays located elsewhere in the Delta, and will be available for future telemetry projects in the Bypass (e.g. evaluation of newly designed passage structures).

If the salmon isotope work (Task 4) successfully identifies an isotopic signature of the Yolo Bypass in juvenile salmon otoliths, this will be widely applicable, relatively inexpensive, and powerful tool for evaluating the portion of various species' populations that utilize the Bypass.

9. Qualifications

Dr. Ted Sommer has and MS and PhD in Ecology from UC Davis, where he studied under noted fisheries biologist Dr. Peter Moyle. He is presently Program Manager II at Department of Water Resources, where he does research on the San Francisco estuary as part of the Interagency Ecological Program. Dr. Sommer is one of the state's leading authorities on fishes of the San Francisco estuary, particularly with respect to floodplain habitat and native fishes such as splittail, delta smelt, and Chinook salmon. He founded IEP's Yolo Bypass study in the late 90s and has conducted numerous studies on the floodplain since then. Dr. Sommer has published extensively, with over 26 research articles since 2001 on broad topics including estuarine and floodplain ecology, fisheries biology (including striped bass), phytoplankton, zooplankton, aquatic insects, and hydrology.

Dr. Peter (Pete) Klimley received a M. Sci. in Biological Oceanography from the Rosenstiel School of Marine and Atmospheric Science and a Ph.D. from Scripps Institution of Oceanography. He is currently an Adjunct Professor in the Department of Wildlife, Fish, and Conservation Biology at the University of California, Davis and is Director of the Biotelemetry Laboratory, where he supervises telemetric studies conducted by staff, graduate students, and postgraduate fellows. His specific research interests are marine and anadromous fisheries biology, ecology, and oceanography, biotelemetry: development of behavioral and environmental sensors, computer-decoded telemetry, the utilization of automated data logging and archival tags. He was intimately involved in the engineering development and initial biological testing of the technology (i.e., coded ultrasonic beacons and automated listening stations) to be used in the Yolo Bypass in the mid 1980's (see review, Klimley *et al.*, 1998) and has utilized this methodology to determine the site fidelity and response to upwelling events by scalloped hammerhead sharks, school cohesion in yellowfin tuna, predator prey relationships in white sharks, the impediment to the spawning migration of green sturgeon caused by Red Bluff Diversion Dam (Hublein *et al.*, 2009), and the value of the closure of the delta cross channel effect in reducing salmon smolt mortality during outmigration (Perry *et al.*, 2009). Currently, members of the Biotelemetry Laboratory are investigating the behavior, ecology, and physiology of a diversity of species, including terrestrial species such as tortoises, ant eaters, and panthers and marine species such as abalone, salmon, sturgeon, largemouth bass, rays, sharks, and whales. He has published close to 100 scientific articles, written three books, and has been in three dozen film documentaries about sharks. He will be overall supervisor of the telemetry task, ensuring that the task is completed and the results published in the scientific literature. **For more details see:** http://wfcb.ucdavis.edu/www/faculty/Pete/index.html.

Dr. Bernie May received his PhD is Genetics from the Pennsylvania State University in 1980. He served for 14 years at Cornell University as Director of the Cornell Laboratory for Ecological and Evolutionary Genetics. For the past thirteen years he has been the Director of the Genomic Variation Laboratory in the Department of Animal Science at UCDavis He currently has ten PhD students and three post-docs working in his laboratory who use a variety of molecular techniques (AFLPs, microsatellites, SNPx, sequencing, microarrays, etc.) to study genomic variation in natural and aquacultural populations. He has published over 160 scientific papers on questions related to genomic structure, linkage of markers to QTLs, population analysis, mixed stock analysis, genomic manipulation, effects of non-indigenous species/populations, effects of toxicants on gene pools, and isolate identification in a wide range of fish, fungi, birds, mammals, plants, and invertebrates. For more details see: http://genome-lab.ucdavis.edu. Dr. May has previously been awarded CALFED grants, listed below with the project status.

Contract #	Title	PI	Outcome
unavailable	Biological assessment of green sturgeon in the Sacramento-San Joaquin watershed	J. Cech	*completed as contracted*
P014004	San Joaquin River basin Fall-run chinook salmon genetic baseline and discrimination	B. May	*completed as contracted*
1132321G005	Biological assessment of green sturgeon in the Sacramento-San Joaquin watershed	A. Klimley	*completed as contracted*
02P34	Restoration of Sacramento perch to San Francisco Estuary	P. Moyle	*completed as contracted*
113322J006	Sex-reversal in Central Valley Chinook salmon: occurrence and population genetic consequences	B. May	*completed as contracted*
4600002763	Population genetics of splittail	B. May	*completed as contracted*
02DP57	Biological assessment of green sturgeon in the Sacramento-San Joaquin watershed	A. Klimley	*completed as contracted*
05WRGR0012	Are apparent sex-reversed Chinook salmon a symptom of genotoxicity?	B. May	*completed as contracted*
1036	**Predicting the effects of invasive hydrozoa (jellyfish) on pelagic organisms under changing saline and temperature regimes**	B. May	*partially completed*
E078004	**Population biology, life history, distribution, and environmental optima of green sturgeon**	A. Klimley	*partially completed*

Dr. Rachel Barnett-Johnson is a fisheries ecologist in the Applied Sciences division of U.S Bureau of Reclamation. She received her PhD in Ecology and Evolutionary Biology from the University of California Santa Cruz (UCSC). Dr. Barnett-Johnson is affiliated faculty at the Institute of Marine Sciences at UCSC and directs an active research laboratory. She has 13 years of research experience working on the freshwater, estuarine, and ocean ecology of Chinook salmon from the California Central Valley. Her research program aims to understand mechanisms of population persistence and aid in determining critical habitats for the reproduction, survival, and growth of endangered species and those targeted by fisheries. Dr. Barnett-Johnson has extensive expertise and publications focusing on otolith microchemistry, otolith microstructure and integration of these techniques with molecular tools to better understand migration and connectivity in salmon populations. For more details on publications see: http://ims.ucsc.edu/facres/index.html.

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Section 7: Project Budget

1. **Detailed Project Budget** ***(Excel spreadsheets can be used)***

Please see attached sheets.

2. **Budget justification:**

Task 1: Telemetry
Cost: $399, 536 over 2 years

Personal Services ($151, 978)

The principal investigator of the telemetry task will be Dr. A. Peter Klimley (APK), *Adjunct Professor* and Director of the Biotelemetry Laboratory at UC Davis. He will design the study, oversee the purchase and deployment of tags and receivers, and ensure that semi-annual reports are produced in a timely manner for the California Department of Fish and Game.

The *Graduate Student Researcher* will be mentored by APK and will be a student in the Ecology Graduate Group at UC Davis. In such a capacity, he or she will develop a graduate research project within the scope of this task. APK will provide input along with Drs. Ted Sommer and Louise Conrad, in the context such that the student will receive input from the UC Davis faculty on the appropriateness of the study for graduate credit. The student will, along with the staff researcher, purchase tags and monitors, tag fish and deploy the monitors, and analyze the resulting files of tag detections. The student will be expected to produce a dissertation consisting of three articles publishable in the scientific literature.

The *Junior Specialist* will carrying out many of the routine research activities such as getting permits, operating the truck and research vessel, tagging fish, installing monitors at sites, and retrieving the monitors for downloading of the files of tag detections. This person will work with the graduate student as many of the research activities will demand a team of two to complete them in a safe manner. This person will also be expected to participate in data analysis, report writing, and eventual publication of the results.

Operating Expenses ($173,289)

We will purchase 15 *RECODE automated monitors (Vemco Ltd., VR-02, 69 kHz)* 15 *RECODE automated monitors* (Vemco Ltd., VR-02, 180 kHz) during Year 1 for tracking adult and juvenile fish, respectively. Funding is requested for *hardware for moorings*, consisting of a pyramid anchor, chain, shackles, and a buoy. A *temperature logger* will be placed on each of the monitors. We will place 25 *coded ultrasonic beacons*, varying in life from five to 10 years depending on their size (i.e., V13 with a 13 mm dia; V16 with a 16 mm dia), on 25 adult Chinook salmon and 25 white sturgeon during Years 1 and 2 of the study. Our team will place *coded miniature beacons (Vemco Ltd.,V6 or V5)* on 50 hatchery-origin fall-run Chinook smolts and release them just downstream of the Fremont Weir at the head of the Yolo Bypass floodplain during Years 1 and 2. *Surgical materials* will need to be purchased such as scapels, surgical staples, and suturing material.

Travel ($5,400)

A *panel truck* will be rented on a monthly basis for various tasks including use for transporting fish from the Coleman Hatchery to the Center for Aquatic Biology and Aquaculture, where they will be kept for tagging, and later transported to the Yolo Bypass for release. The truck will also be used to tow a research vessel to the site for the interrogation of the monitors, when water is present in the Yolo Bypass. Requested are funds to purchase gasoline for boat operation. Lastly, we request funds for the payment of registration for the three investigators involved in the project to attend the *State of the Estuary Conference* during Year 1 and the *Delta-Bay Science Symposium* during Year 2.

Miscellaneous (no indirect cost)

Funds are requested to pay for the *tuition* of the graduate students for each of three quarters during both years of the contract. This is a requirement of all contracts, on which graduate students work at UC Davis.

Task 2: Chinook salmon run identification and investigation of thermal stress
Total Budget costs: $222,025.94 over two years
<u>Personal Services: $112,770.75</u>

Dr. May will devote 173 hours per year for project coordination and oversight. Dr. Meek will devote 520-785 hours per year for daily supervision of sample collection, laboratory research, data analysis, and manuscript preparation. A laboratory technician (to be determined) will devote 865-1040 hours per year for microsatellite/SNP genotyping and gene expression sample processing and data collection. Fringe benefits are 27-27.8%/year (Dr. May), 19.6-19.7%/year (Dr. Meek), and 40.2-41.2%/year (laboratory technician) as dictated by UC Davis policy. Matching funds will be provided in the form of salary and benefits for Dr. Josh Israel (Project Collaborator), United States Bureau of Reclamation (172 hours, total $9501). Dr. Israel will assist with project oversight and provide expertise and support on Central Valley salmonids, sample collection, and genetic studies.

<u>Operating Expenses: $64,850.00</u>

Funds of $29,250 in year 1 and $26,300 in year 2 are requested to cover the cost of molecular analyses for run identification (1737 samples) and thermal stress determination (200 samples). Additional expenses include office supplies ($400/year), publication costs ($500-$1000/year), equipment lease and maintenance ($2000/year), and travel to conferences and field sites ($1500/year).

Task 3: Historical Salmon Data Analyses
Cost: $100,449 over two years

<u>Personal Services: $60, 249</u>

Kevin Reece (CDWR, Environmental Scientist) will perform the data synthesis, analyses, and writing for this task, with oversight from Dr. Ted Sommer and Louise Conrad (Program Manager II and Senior Environmental Scientist, respectively). The data management, analyses and interpretation for this work will take place in Year 1, and will occupy approximately 40% of Reece's time. In Year 2, Reece will finish writing up the paper, with review and other support from Sommer and Conrad.

<u>Operating Expenses: $0</u>

As this task is purely data synthesis and CDWR is already equipped with the software and computers necessary, there is no cost of materials.

Task 4: Salmon Isotope work
Cost: $49, 532

The majority of expenses for the isotope work are to support a technician to prepare samples for isotope analyses (~$14,000). Analytical costs ($20,000) of isotope analysis of otoliths ($100/sample) and gut contents ($40/sample) and travel for two people to participate in the analytical session at UCLA ($5,000).

Task 5: Food web studies
Cost: $104,676

<u>Personal Services: $60,760</u>

Brett Harvey (CDWR, Environmental Scientist) will be the lead person for both the data analyses and field sampling components that comprise this task. Forty percent of his time in Year 1 will be devoted to both data management and analyses (primarily), with some time in the field collecting invertebrate and plankton samples during the summer and fall months. In this first year, he will be assisted by Kevin Reece for field collections. The bulk of the analyses will take place in Year 1, such that Year 2 will be devoted to finishing field collections, completing analyses, and writing up results. Over both years, Sommer and Conrad will provide oversight for this task.

<u>Operating Expenses: $0</u>

CDWR possesses all of the sampling gear (nets, boats, data loggers, etc.) necessary for sample collection, due to the long-term monitoring project that is already in place. Therefore, funds for operating expenses are not requested for this task.

3. Administrative overhead:

Tasks 1, 3, 4: Telemetry, Salmon Genetics and Stress, and Salmon Isotope
Overhead Costs: $74,339 (Telemetry) and $44,405 (Salmon Genetics and Stress)

These tasks will be carried out by Principal Investigators from the University of California. Drs. Klimley and May are at UC Davis. Dr. Barnett-Johnson, Task 4, is affiliated faculty at the Institute of Marine Sciences at UCSC, in addition to being a fisheries Ecologist for USBR. Since the proposed salmon isotope work for which she is the PI will take place out of her laboratory at UCSC, the overhead rate for the University of California will apply to this task. The administrative overhead rate is the same for all of these tasks.

The current indirect cost rate for VM:APC is 25% with all California State Agencies (Waiver # 03R-135, shown below).

Class Waiver	No.: **03R-135**	Date Approved: **5/9/2003**	Sponsor Code:
Campus: **OP**	Reason: **C** [A=vital interest; C=sponsor policy]		
Sponsor Name: *CALIFORNIA STATE AGENCIES*			
Project Title: **CALIFORNIA STATE AGENCY AGREEMENTS****			
Waiver Rate: **25.00% MTDC***			
Notes: *UNLESS OTHERWISE SET FORTH IN STATUTE, REGULATION, OR PUBLISH POLICY THAT APPLIES TO ALL RECIPIENTS. C&G MEMO 03-02. SEE OTHER STATE CLASS WAIVERS FOR SPECIFIC PROGRAMS.			

Tasks 3 and 5: Historical Salmon Data Analyses and Food Web Studies
Overhead Costs: $40,200 (Salmon Data Analyses) and $44,582 (Food Web Studies)

Both of these tasks will be carried out by CDWR staff. For CDWR, the administrative overhead rate is 95.08%. These funds are devoted to salaries, healthcare benefits, and retirement costs for all managerial-level staff at CDWR.

Summary Budget

	Task 1: Telemetry UC Davis, Telemetry Lab	Task 2: Salmon Genetics & Stress UC Davis, Genomic Variation Lab	Task 3: Salmon Analyses DWR
PERSONAL SERVICES	$ 151,978	$ 112,771	$ 60,249
OPERATING EXPENSES	$ 173,219	$ 64,850	$ -
SUBTOTAL	$ 325,197	$ 177,621	$ 60,249
ADMINISTRATIVE OVERHEAD	$ 74,339	$ 44,405	$ 40,200
GRAND TOTAL	**$ 399,536**	**$ 222,026**	**$ 100,449**

	Task 4: Isotopes USBR	Task 5: Food Web CDWR
PERSONAL SERVICES	$ 14,347	$ 61,426
OPERATING EXPENSES	$ 25,474	$ -
SUBTOTAL	$ 39,821	$ 61,426
ADMINISTRATIVE OVERHEAD	$ 10,180	$ 44,582
GRAND TOTAL	**$ 50,000**	**$ 106,008**

	Project Total
PERSONAL SERVICES	**$ 324,998**
OPERATING EXPENSES	**$ 238,069**
SUBTOTAL	**$ 563,067**
ADMINISTRATIVE OVERHEAD	**$ 158,945**
GRAND TOTAL	**$ 878,020**

Task 1. Telemetry

PERSONAL SERVICES			Year 1 Totals			Year 2 Totals	Task Total
	Number of Hours	*Hourly Rate*	*Subtotal*	*Number of Hours*	*Hourly Rate*	*Subtotal*	
Staff Level							
Adjunct Professor III (A. Peter Klimley, Ph.D.): 2 mo @ 100%	352	49	$17,382	352	49	$17,382	
Graduate Student Researcher 1 Yr 1, 2 Yr 2 (To be named): 9 mo @ 50%, 3 mo @ 100%	1,320	15	$20,262	1,320	17	$21,846	
Junior Specialist I Yr 1, 2 Yr 2 (To be named): 6 mo @ 100%	1,056	16	$16,833	2,112	17	$35,904	
Staff Benefits		%			%		
Adjunct Professor III: 24% X salary		24%	$4,172		24%	$4,172	
Graduate Student Researcher: 2% X salary		2%	$405		2%	$437	
Junior Specialist: 25% X salary		25%	$4,208		25%	$8,976	
Total Personal Services			**$63,261**			**$88,716**	**$151,978**

OPERATING EXPENSES						
Description						
Supplies	*Each*	*Quantity*	*Total*	*Each*	*Quantity*	*Total*
RECODE automated monitors, 180 kHz (Vemco Ltd) for tagging juveniles: 18 @ $1400 ea	1,400	18	$25,200			$-
RECODE automated monitors, 69 kHz (Vemco Ltd.), for tagging adults: 18 @ $1400 ea	1,400	18	$25,200			$-
Moorings: anchor, chain, shackles, and buoys, 18 @ $100 ea			$1,800			$300
Temperature loggers (ONSET): 8 loggers @ $130 ea			$1,040			$1,040
Replacement batteries for monitors: 18 at $60 ea						$900
Dummy tags	10	50	$500			
RECODE coded ultrasonic beacons, V5 or V6 for smolt tagging: 50 at $330 ea for deployment during Yr 1 & Yr 2	330	50	$16,500	330	50	$16,500
RECODE coded ultrasonic beacons, V13 or V16 for tagging Chinook, splittail, sturgeon(Vemco Ltd.): 75 @ $330 ea	330	75	$24,750	330	75	$24,750
Surgical equipment (scapels, surgical stablers, etc): $200/yr			$200			$200
Subtotal			$95,190			$43,690

TRAVEL			
Truck rental for tagging and downloads @ $900/mo+ $300/gasoline for 2 months	$2,400	$2,400	
Boat operation: 5 days @ $50/day in gasoline	$250	$250	
Registration for scientific meetings: 3 persons @ 200/pers./meeting	$600	$600	
Subtotal	$3,250	$3,250	
Miscellaneous (no indirect cost)			
Tuition remission for graduate student: $13,257 Year 1, $14,582	$13,257	$14,582	
Subtotal	$13,257	$14,582	
Total Operating Expenses	**$111,697**	**$61,522**	**$173,219**
SUBTOTAL	$174,958	$150,238	**$325,197**
OVERHEAD @ 25%, not including Equipment and Tuition Remision Less Tuition Remission	$40,425	$33,914	**$74,339**
GRAND TOTAL	**$215,384**	**$184,152**	**$399,536**

Task 2. Genetics and Stress

PERSONAL SERVICES			Year 1 Totals			Year 2 Totals	Task Total
	Number of Hours	*Hourly Rate*	*Subtotal*	*Number of Hours*	*Hourly Rate*	*Subtotal*	
Staff Level							
1. Dr.Bernie May (Adjunct Professor)	173	67.5	$11,678	173	70.20	$12,145	
2. Dr. Mariah Meek (Post-doctoral researcher)	520	21.68	$11,274	785	22.55	$17,700	
3. Laboratory Technicians	1040	17.5	$18,200	865	18.20	$15,743	
Staff Benefits							
1. Dr.Bernie May (Adjunct Professor)		27.00%	$3,153		27.80%	$3,376	
2. Dr. Mariah Meek (Post-doctoral researcher)		19.60%	$2,210		19.73%	$3,491	
3. Laboratory Technicians		40.20%	$7,316		41.20%	$6,486	
Total Personal Services			**$53,830**			**$58,941**	**$112,771**
OPERATING EXPENSES							
Materials and Supplies							
Molecular analysis--Run identification	937 samples		$20,250.00	800 samples		$17,300.00	
Molecular analysis--Thermal stress	100 samples		$9,000.00	100 samples		$9,000.00	
Office supplies			$400.00			$400.00	
Publication charges			$500.00			$1,000.00	
Equipment lease and maintenance			$2,000.00			$2,000.00	
TRAVEL			$1,500.00			$1,500.00	
Total Operating Expenses			**$33,650**			**$31,200**	**$64,850**
SUBTOTAL			**$87,480**			**$90,141**	**$177,621**
ADMINISTRATIVE OVERHEAD (@ 25 %)			**$21,870**			**$22,535**	**$44,405**
GRAND TOTAL			**$109,350**			**$112,676**	**$222,026**

Task 3. Salmon Data Analyses

	Year 1 Totals			Year 2 Totals			Task Total
PERSONAL SERVICES							
	Number of Hours	*Hourly Rate*	*Subtotal*	*Number of Hours*	*Hourly Rate*	*Subtotal*	
Staff Level							
Sommer, Program Manager II	52	$45.49	$2,365	52	$45.49	$2,365	
Conrad, Senior ES, Base level (5% time)	52	$34.06	$1,771	52	$34.06	$1,771	
Reece, ES Range C, Step 2	832	$31.04	$25,825	416	$31.04	$12,913	
Staff Benefits		@ %			@ %		
Sommer, Program Manager II		28.16%	$666		28.16%	$666	
Conrad, Senior ES, Base level		28.16%	$499		28.16%	$499	
Reece, ES Range C, Step 2		28.16%	$7,272		28.16%	$3,636	
Total Personal Services			$38,399			$21,850	**$60,249**
OPERATING EXPENSES							
Materials							
	Each	*Quantity*	*Total*	*Each*	*Quantity*	*Total*	
None required.							
Total Operating Expenses/Equipment			$-			$-	$-
SUBTOTAL			**$38,399**			**$21,850**	**$60,249**
ADMINISTRATIVE OVERHEAD (@ 95.08%, not including benefits and equipment)			**$26,239**			**$13,961**	**$40,200**
GRAND TOTAL			**$64,638**			**$35,812**	**$100,449**

Task 4. Isotopes

PERSONAL SERVICES			Year 1 Totals			Year 2 Totals	Task Total
	Number of Hours	*Hourly Rate*	*Subtotal*	*Number of Hours*	*Hourly Rate*	*Subtotal*	
Staff Level							
Laboratory Assistant III (George Whitman)	300	$17.22	$5,166	300	$17.74	$5,322	
Staff Benefits		%			%		
Laboratory Assistant III (George Whitman)		36.79%	$1,901		36.79%	$1,958	
Total Personal Services			**$7,067**			**$7,280**	**$14,347**
OPERATING EXPENSES	*Each*	*Quantity*	*Total*	*Each*	*Quantity*	Total	
Sulfur isotopes gut contents (UK instrument) $40/sample for 250 samples	$40	250	$10,000				
Sulfur isotopes otoliths (UCLA instrument) $100/otolith (N=100 otoliths)				$100	100	$10,000	
Miscellaneous Materials & Supplies			$274			$200	
TRAVEL							
UCLA						$5,000	
Total Equipment			**$10,274**			**$15,200**	**$25,474**
SUBTOTAL			$17,341			$22,480	**$39,821**
ADMINISTRATIVE OVERHEAD (@ 25% Year 1, 26% Year 2)			$4,335			$5,845	**$10,180**
GRAND TOTAL			$21,676			$28,325	**$50,000**

Task 5. Food Web Analyses

PERSONAL SERVICES			Year 1 Total			Year 2 Total	Task Total
Staff Level	*Number of Hours*	*Hourly Rate*	*Total*	*Number of Hours*	*Hourly Rate*	*Total*	
Sommer, Program Manager II	52	$45.49	$2,365	52	$45.49	$2,365	
Conrad, Senior ES, Base level (5% time)	52	$34.06	$1,771	52	$34.06	$1,771	
Harvey, ES Range C, Step 1	832	$29.56	$24,594	416	$29.56	$12,297	
Reece, ES Range C, Step 2	208	$31.04	$6,456	0	$31.04	$-	
Staff Benefits		@ %			@ %		
Sommer, Program Manager II		28.16%	$666		28.16%	$666	
Conrad, Senior ES, Base level		28.16%	$499		28.16%	$499	
Harvey, ES Range C, Step 1		28.16%	$6,926		28.16%	$3,463	
Reece, ES Range C, Step 2		28.16%	$1,818		28.16%	$-	
Total Personal Services			**$42,730**			**$18,696**	**$61,426**
OPERATING EXPENSES							
Materials	*Each*	*Quantity*	*Total*	*Each*	*Quantity*	*Total*	
None required.							
Total Operating Expenses/Equipment			$-			$-	$-
SUBTOTAL			**$42,730**			**$18,696**	**$61,426**
ADMINISTRATIVE OVERHEAD (@ 95.08%, not including benefits and equipment)			**$31,207**			**$13,376**	**$44,582**
GRAND TOTAL			**$73,937**			**$32,072**	**$106,008**