Effects of Predation Dynamics on Outmigrating Salmon in the Delta

Project Information

1. **Proposal Title:**

   Effects of Predation Dynamics on Outmigrating Salmon in the Delta

2. **Proposal applicants:**

   Sharon Kramer, Stillwater Sciences
   Scott Wilcox, Stillwater Sciences
   Bruce Orr, Stillwater Sciences
   Frank Ligon, Stillwater Sciences

3. **Corresponding Contact Person:**

   Sharon Kramer
   Stillwater Sciences
   850 G Street, Suite K Arcata, CA 95521
   707 822-9607
   sharon@stillwatersci.com

4. **Project Keywords:**

   Anadromous salmonids
   Fish mortality/fish predation
   Nonnative Invasive Species

5. **Type of project:**

   Research

6. **Does the project involve land acquisition, either in fee or through a conservation easement?**

   No

7. **Topic Area**:

   Importance of the Delta for Salmon

8. **Type of applicant:**

   Private for profit

9. **Location - GIS coordinates:**

Latitude:	38.017
Longitude:	-121.317
Datum:	NAD83

Describe project location using information such as water bodies, river miles, road intersections, landmarks, and size in acres.

Sampling will focus on two Delta locations: one site on the lower Sacramento River, near Ida Island and Isleton, and one site on the lower San Joaquin River, near the confluence of Old River.

10. **Location - Ecozone:**

    1.1 North Delta, 1.3 South Delta

11. **Location - County:**

    Sacramento, San Joaquin

12. **Location - City:**

    Does your project fall within a city jurisdiction?

    No

13. **Location - Tribal Lands:**

    Does your project fall on or adjacent to tribal lands?

    No

14. **Location - Congressional District:**

    11

15. **Location:**

    California State Senate District Number: 5

    California Assembly District Number: 26, 10

16. **How many years of funding are you requesting?**

    2.5

17. **Requested Funds:**
    a) Are your overhead rates different depending on whether funds are state or federal?

       No

       If no, list single overhead rate and total requested funds:

Single Overhead Rate: 131.14

Total Requested Funds: $761,443.00

b) Do you have cost share partners already identified?

No

c) Do you have potential cost share partners?

No

d) Are you specifically seeking non-federal cost share funds through this solicitation?

No

If the total non-federal cost share funds requested above does not match the total state funds requested in 17a, please explain the difference:

18. **Is this proposal for next-phase funding of an ongoing project funded by CALFED?**

No

Have you previously received funding from CALFED for other projects not listed above?

Yes

If yes, identify project number(s), title(s) and CALFED program.

98E-09	**Merced River Corridor Restoration Plan-Phase II**	**ERP**
2000 E-05	**Merced River Corridor Restoration Project-Phase III**	**ERP**
99-B152	**A Mechanistic Approach to Riparian Restoration in the San Joaquin Basin**	**ERP**
Service Agreement #010801	**Tuolumne River Coarse Sediment Management Plan**	**CALFED Service Agreement**
Contract B-81491	**Saeltzer Dam Removal Analysis**	**CALFED Contract**

19. **Is this proposal for next-phase funding of an ongoing project funded by CVPIA?**

No

Have you previously received funding from CVPIA for other projects not listed above?

Yes

If yes, identify project number(s), title(s) and CVPIA program.

99173	**Merced River Corridor Restoration Plan-Phase I**	**AFRP**
CVPIA 11332-9-MO79	**Merced River: Ratzlaff Project**	**AFRP**
CVPIA 11332-9-MO80	**Stanislaus River: 2 Mile Bar**	**AFRP**
CVPIA 11332-0-MO09	**Stanislaus River: Smolt Survival**	**AFRP**
CVPIA 11332-1-GO06	**Calaveras Salmonid Limiting Factors Study**	**AFRP**

20. **Is this proposal for next-phase funding of an ongoing project funded by an entity other than CALFED or CVPIA?**

No

Please list suggested reviewers for your proposal. (optional)

Larry Brown	**US Geological Survey**	**(916)278-3098**	**lrbrown@usgs.gov**
Randy Brown	**CA Department of Water Resources (retired)**	**(916)227-7531**	**rbrown@water.ca.gov**
Ted Sommer	**CA Department of Water Resources**	**(916) 227-7537**	**tsommer@water.ca.gov**
Peter Moyle	**UC Davis**	**(530) 752-3576**	**pbmoyle@ucdavis.edu**

21. **Comments:**

Environmental Compliance Checklist

<u>Effects of Predation Dynamics on Outmigrating Salmon in the Delta</u>

1. **CEQA or NEPA Compliance**
   a) Will this project require compliance with CEQA?

      No
   b) Will this project require compliance with NEPA?

      No
   c) If neither CEQA or NEPA compliance is required, please explain why compliance is not required for the actions in this proposal.

      This project requires no engineering, and is based on monitoring and field work.

2. **If the project will require CEQA and/or NEPA compliance, identify the lead agency(ies).** *If not applicable, put "None".*

   <u>CEQA Lead Agency:</u>
   <u>NEPA Lead Agency (or co-lead:)</u>
   <u>NEPA Co-Lead Agency (if applicable):</u>

3. **Please check which type of CEQA/NEPA documentation is anticipated.**

   CEQA
   -Categorical Exemption
   -Negative Declaration or Mitigated Negative Declaration
   -EIR
   Xnone

   NEPA
   -Categorical Exclusion
   -Environmental Assessment/FONSI
   -EIS
   Xnone

   If you anticipate relying on either the Categorical Exemption or Categorical Exclusion for this project, please specifically identify the exemption and/or exclusion that you believe covers this project.

4. **CEQA/NEPA Process**
   a) Is the CEQA/NEPA process complete?

      None

   b) If the CEQA/NEPA document has been completed, please list document name(s):

5. **Environmental Permitting and Approvals** (*If a permit is not required, leave both Required? and Obtained? check boxes blank.*)

LOCAL PERMITS AND APPROVALS

Conditional use permit

Variance

Subdivision Map Act

Grading Permit

General Plan Amendment

Specific Plan Approval

Rezone

Williamson Act Contract Cancellation

Other

STATE PERMITS AND APPROVALS

Scientific Collecting Permit	Required
CESA Compliance: 2081	
CESA Compliance: NCCP	
1601/03	
CWA 401 certification	
Coastal Development Permit	
Reclamation Board Approval	
Notification of DPC or BCDC	
Other	

FEDERAL PERMITS AND APPROVALS

ESA Compliance Section 7 Consultation	Required
ESA Compliance Section 10 Permit	Required
Rivers and Harbors Act	
CWA 404	
Other	

PERMISSION TO ACCESS PROPERTY

Permission to access city, county or other local agency land.
Agency Name:

Permission to access state land.
Agency Name:

Permission to access federal land.
Agency Name:

Permission to access private land.
Landowner Name:

6. **Comments.**

Regarding permission to access property not owned by the applicant: public boat launching facilities will be used and sampling will occur in public waters.

Land Use Checklist

Effects of Predation Dynamics on Outmigrating Salmon in the Delta

1. **Does the project involve land acquisition, either in fee or through a conservation easement?**

   No

2. **Will the applicant require access across public or private property that the applicant does not own to accomplish the activities in the proposal?**

   Yes

3. **Do the actions in the proposal involve physical changes in the land use?**

   No

   If you answered no to #3, explain what type of actions are involved in the proposal (i.e., research only, planning only).

   research only

4. **Comments.**

Conflict of Interest Checklist

Effects of Predation Dynamics on Outmigrating Salmon in the Delta

Please list below the full names and organizations of all individuals in the following categories:

- Applicants listed in the proposal who wrote the proposal, will be performing the tasks listed in the proposal or who will benefit financially if the proposal is funded.
- Subcontractors listed in the proposal who will perform some tasks listed in the proposal and will benefit financially if the proposal is funded.
- Individuals not listed in the proposal who helped with proposal development, for example by reviewing drafts, or by providing critical suggestions or ideas contained within the proposal.

The information provided on this form will be used to select appropriate and unbiased reviewers for your proposal.

Applicant(s):

Sharon Kramer, Stillwater Sciences
Scott Wilcox, Stillwater Sciences
Bruce Orr, Stillwater Sciences
Frank Ligon, Stillwater Sciences

Subcontractor(s):

Are specific subcontractors identified in this proposal? Yes

If yes, please list the name(s) and organization(s):

Chuck Hanson Hanson Environmental, Inc.

Helped with proposal development:

Are there persons who helped with proposal development?

Yes

If yes, please list the name(s) and organization(s):

Steve Lindley US National Marine Fisheries Service

Bruce Herbold US Environmental Protection Agency

Comments:

Budget Summary

Effects of Predation Dynamics on Outmigrating Salmon in the Delta

Please provide a detailed budget for each year of requested funds, indicating on the form whether the indirect costs are based on the Federal overhead rate, State overhead rate, or are independent of fund source.

Independent of Fund Source

Year 1												
Task No.	**Task Description**	**Direct Labor Hours**	**Salary *(per year)***	**Benefits *(per year)***	**Travel**	**Supplies & Expendables**	**Services or Consultants**	**Equipment**	**Other Direct Costs**	**Total Direct Costs**	**Indirect Costs**	**Total Cost**
1	Project permitting	164	$5,802	$1,959	0	0	0	0	286	286.0	$9,173	286.00
2A	Project Location and Habitat Selection	349	$11,508	$3,886	$3,600	0	$1,586	2550	539	3089.0	$18,965	3089.00
2B	Weekly predator sampling for food habits	1425	$67,533	$22,806	$36,000	$4,000	$5,703	33850	4897	38747.0	$114,880	38747.00
2C	Opportunistic predator sampling for food habits	835	$40,918	$13,818	$18,000	$2,500	$5,411	4600	2614	7214.0	$67,801	7214.00
2D	Analysis of stomach contents	307	$12,837	$4,335		$2,500		0	1004	1004.0	$20,581	1004.00
3	Predator tracking: predator site fidelity	307	$6,876	$2,322		$10,090	$5,000	0	502	502.0	$12,396	502.00
4	Data Entry, QA/QC and Analysis	82	$6,472	$2,185			$1,500	0	113	113.0	$10,361	113.00
5	Reports and presentations	80	$8,738	$2,951		$150	$2,160	0	282.3	282.3	$14,031	282.30
		3549	0.00	0.00	0.00	0.00	0.00	41000.00	10237.30	51237.30	0.00	51237.30

Year 2												
Task No.	**Task Description**	**Direct Labor Hours**	**Salary *(per year)***	**Benefits *(per year)***	**Travel**	**Supplies & Expendables**	**Services or Consultants**	**Equipment**	**Other Direct Costs**	**Total Direct Costs**	**Indirect Costs**	**Total Cost**
3	Predator tracking: predator site fidelity	307	$7,151	$2,415		$10,090	$5,000	0	502	502.0	$12,829	502.00
4	Data Entry, QA/QC and Analysis	164	$6,730	$2,273			$1,500		113	113.0	$10,769	113.00
5	Reports and presentations	200	$12,117	$4,092		$200	$2,880		376.4	376.4	$19,443	376.40
		671	0.00	0.00	0.00	0.00	0.00	0.00	991.40	991.40	0.00	991.40

Year 3													
Task No.	**Task Description**	**Direct Labor Hours**	**Salary *(per year)***	**Benefits *(per year)***	**Travel**	**Supplies & Expendables**	**Services or Consultants**	**Equipment**	**Other Direct Costs**	**Total Direct Costs**	**Indirect Costs**	**Total Cost**
5	Reports and presentations	519	$9,451	$3,192		$150	$2,160		282.3	282.3	$15,155	282.30
		519	0.00	0.00	0.00	0.00	0.00	0.00	282.30	282.30	0.00	282.30

Grand Total=52511.00

Comments.

On-line budget forms do not appear to be adding task or year totals correctly. Complete budget forms are also attached to proposal package.

Budget Justification

Effects of Predation Dynamics on Outmigrating Salmon in the Delta

Direct Labor Hours. Provide estimated hours proposed for each individual.

Employee Hours Peter Baker 520 Ethan Bell 368 Davis Tech 3548 AJ Keith 208 Sapna Khandwala 160 Sharon Kramer 618 Steve Kramer 836 Frank Ligon 36 Whitney Sparks 40 Dirk Pedersen 668 Angela Percival 88 Scott Wilcox 376

Salary. Provide estimated rate of compensation proposed for each individual.

Employee Rate Peter Baker $37.57 Ethan Bell $24.07 Davis Tech $16.31 AJ Keith $27.58 Sapna Khandwala $23.62 Sharon Kramer $46.25 Steve Kramer $31.72 Frank Ligon $50.30 Whitney Sparks $15.75 Dirk Pedersen $30.10 Angela Percival $30.10 Scott Wilcox $48.68

Benefits. Provide the overall benefit rate applicable to each category of employee proposed in the project.

Stillwater pays 33.78% in benefits to employees in all categories.

Travel. Provide purpose and estimate costs for all non-local travel.

All travel is from the Bay Area, Sacramento or Arcata to the project site in the Delta, and includes the cost of mileage, lodging and meals. Travel costs to select sampling sites and conduct extensive sampling are estimated to total $57,600.

Supplies & Expendables. Indicate separately the amounts proposed for office, laboratory, computing, and field supplies.

Estimated break-down of supply costs: Office supplies: $2,000 Laboratory supplies: $12,680 Computing supplies: $2,000 Field supplies: $13,000

Services or Consultants. Identify the specific tasks for which these services would be used. Estimate amount of time required and the hourly or daily rate.

Chuck Hanson of Hanson Environmental will provide oversight and assistance throughout the project. Also it is anticipated that portions of the sampling will require two boats, one being supplied by Hanson Environmental. Hanson charges $200 per day for the boat, which includes a pilot. We estimate fuel will cost $50 per day which is not included in the boat rental price. Costs for subconsultant services are included in Tasks 2 through 4, and are estimated to be $32,900.

Equipment. Identify non-expendable personal property having a useful life of more than one (1) year and an acquisition cost of more than $5,000 per unit. If fabrication of equipment is proposed, list parts and materials required for each, and show costs separately from the other items.

Weekly sampling will require the purchase of electrofishing equipment, stationary multi-mesh gill nets, large fyke traps, and hook-and-line sampling equipment. A boat will also be needed (in addition to one being provided by Hanson Environmental). It is assumed that an appropriately equipped vessel can be leased or rented. If this is not the case, Stillwater would be prepared to acquire one and use charge it to the project. Equipment costs total $41,000.

Project Management. Describe the specific costs associated with insuring accomplishment of a specific project, such as inspection of work in progress, validation of costs, report preparation, giving presentatons, reponse to project specific questions and necessary costs directly associated with specific project oversight.

Coordination of field activities is estimated to require a project management cost of $35,400. These costs are budgeted under subtasks 2a, 2b, and 2c. Other project administration, including agency coordination, equipment procurement, permitting, and project oversight is estimated to require $23,000. These costs are budgeted within all tasks.

Other Direct Costs. Provide any other direct costs not already covered.

Costs associated with computer systems and networks are included in Other Direct Costs.

Indirect Costs. Explain what is encompassed in the overhead rate (indirect costs). Overhead should include costs associated with general office requirements such as rent, phones, furniture, general office staff, etc., generally distributed by a predetermined percentage (or surcharge) of specific costs.

Stillwaters indirect costs include office expenses (rent, utilities, telephones, computer supplies, data connectivity, etc.), office staff, insurance, legal and accounting costs, proposal expenses and depreciation for capital items such as furniture and office equipment. As no specific place was provided, contractor fee was also included in the Indirect Costs column.

Executive Summary

<u>Effects of Predation Dynamics on Outmigrating Salmon in the Delta</u>

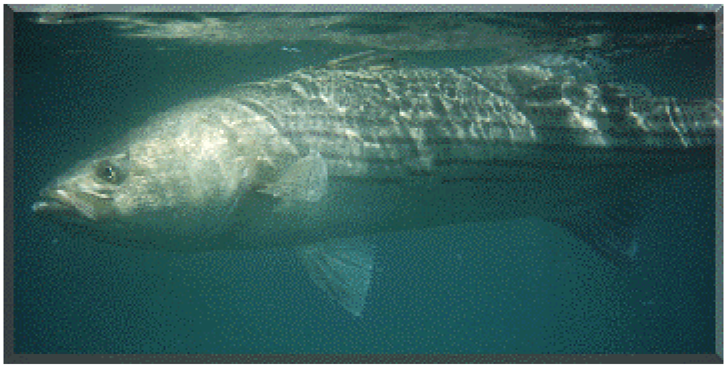
Declines in juvenile salmonid abundance during outmigration through the Sacramento-San Joaquin Delta have been documented, but there is little information on the specific mechanisms associated with Delta mortality. These mechanisms likely include adequate food supplies, effects of contaminants, effects of diversions, and predation. Predation dynamics in Delta habitats during the period of salmonid outmigration is of great interest to fisheries and water managers, but are poorly understood. Moreover, the CALFED goal of creating shallow-water habitats in the Delta could result in habitat that harbors salmonid predators and increases predation pressure on threatened salmonid species. We propose to document the temporal and spatial scales of predation dynamics on outmigrating salmon in the Delta. Specifically, we will assess patterns in the diet of suspected and known predators in the Delta associated with temporal variability in salmon smolt density, evaluating whether the proportion of salmon smolts in predator diets changes over the period of peak outmigration. We will also assess whether predator species composition and predation dynamics varies between different Delta habitat types and locations. This proposed research project will take advantage of existing monitoring programs and hatchery releases to provide relative abundance estimates of salmon smolts as they migrate through the Delta and to guide the timing of our sampling. Our approach will combine traditional fishery study methods, such as food habit studies and catch-per-unit-effort surveys, with technologically advanced techniques, such as radio-tagging to address predator site fidelity. The results of the proposed study will provide important data to inform habitat restoration actions throughout the Delta, particularly in shallow-water habitats. The project will address the specific CALFED goal of creating shallow-water habitats in the Delta and IEPs goal of addressing the factors affecting abundance, distribution, and survival of migrating salmonids in the Delta.

Proposal

Stillwater Sciences

Effects of Predation Dynamics on Outmigrating Salmon in the Delta

Sharon Kramer, Stillwater Sciences
Scott Wilcox, Stillwater Sciences
Bruce Orr, Stillwater Sciences
Frank Ligon, Stillwater Sciences



Effects of Predation Dynamics on Outmigrating Salmon in the Delta

Prepared for
CALFED Ecosystem Restoration Program

Prepared by
Stillwater Sciences
2532 Durant Avenue, Suite 201
Berkeley, CA 94704

October 5, 2001

Stillwater Sciences

A. PROJECT DESCRIPTION: PROJECT GOALS AND SCOPE OF WORK

A.1 Problem

Anadromous salmonid populations in the Sacramento and San Joaquin river basins and the Sacramento-San Joaquin Delta have declined substantially. While declines are being addressed by improving spawning and rearing habitat, the effects of predation dynamics on these populations are poorly understood, particularly in the Delta. Do certain fish predators shift their feeding strategies and locations in response to high densities of outmigrating salmonid smolts, or do predators maintain relatively stable diets on prey that are available year-round? Do different delta habitats influence predation dynamics? Our proposed study will examine predator/prey dynamics and allow CALFED and resource managers to evaluate the relative benefits of various actions to increase survival of outmigrating salmonids.

Declining salmonid populations

Several anadromous salmonid evolutionarily significant units (ESUs) in the Sacramento and San Joaquin river basins and the Sacramento-San Joaquin Delta are in decline and listed under the federal Endangered Species Act (ESA), including endangered Sacramento River ESU winter-run chinook salmon (*Oncorhynchus tshawytscha*), threatened Central Valley ESU spring-run chinook salmon (*O. tshawytscha*), and threatened Central Valley ESU steelhead (*O. mykiss*). Juvenile salmonid mortality in the lower Sacramento and San Joaquin rivers and the Sacramento-San Joaquin Delta is known to be fairly high (USFWS 2000), so a better understanding of the causes of this mortality is of potential interest to fisheries and water managers. Additionally, two other fish species in this region are listed as threatened under the ESA: delta smelt (*Hypomesus transpacificus*) and Sacramento splittail (*Pogonichthys macrolepidotus*). Many factors are considered to be contributing to the decline of these fish. Each of these species is likely affected to some degree by the introduction of numerous predaceous fish species in the system.

Predation may act in a density-dependent manner on populations and thus limit population abundance (Hilborn and Walters 1992); it is therefore of particular relevance in this context. The functional response of predators describes the relationship between prey density and the rate at which individual predators consume them (Solomon 1949, Holling 1959). Density-dependent predation rates may occur over some range of prey densities or over some threshold prey density, while density-independent predation rates may occur at high prey densities (Essington et al. 2000). The shape of the functional response curve can be used to indicate whether responses of predators to prey are density-dependent. One way to address this question is to observe predation rates over a wide range of prey densities; however, determining prey availability under natural settings is difficult (Essington et al. 2000).

Introduced and native predator fish species

The lower reaches of the Sacramento and San Joaquin rivers and the Sacramento-San Joaquin Delta are occupied by numerous fish that are known or suspected predators of juvenile anadromous salmonids. Species in the area that are known predators of salmonid smolts include striped bass (*Morone saxatilis*), largemouth and smallmouth bass (*Micropterus salmoides* and *M. dolomieui*), Sacramento pikeminnow (*Ptychocheilus grandis*), channel catfish (*Ictalurus punctatus*), black and white crappies (*Pomoxis nigromaculatus* and *P. annularis*), green sunfish

(*Lepomis cyanellus*), warmouth (*Lepomis gulosus*), and rainbow trout/steelhead (*O. mykiss*). Of these, only pikeminnow and rainbow trout/steelhead are native to the system. Although anadromous salmonids evolved with native fish predators such as Sacramento pikeminnow, introduced species may be better able to prey on juvenile salmonids and other native fish species, or may put additional strain on populations already weakened by multiple stressors. Poe et al. (1994, as cited in Zimmerman 1999) suggested that exotic predators such as smallmouth bass may outcompete northern pikeminnow (a species closely related to the Sacramento pikeminnow) for crayfish, sculpins, and other non-salmonid prey, and that juvenile salmonid predation by northern pikeminnow has increased since the introduction of exotic fish predators in the Columbia River basin. Complex food web changes may also occur in the Sacramento-San Joaquin system considering the significant changes in ecological communities that have taken place there.

The large number of native and introduced fish species now present in the Sacramento-San Joaquin systems makes it difficult to predict the potential effects of management measures to reduce predation. In addition, habitat restoration measures currently underway to increase shallow-water habitats in the Delta may affect predation on outmigrating juvenile salmonids by increasing or decreasing available habitat for native and non-native predator species and/or their prey. This study will increase our understanding of predation dynamics during the peak outmigration period for juvenile chinook salmon. Knowing which species are the most important predators of chinook salmon during outmigration will help in evaluating whether management actions such as habitat enhancement, seasonal flow augmentation, reduction in stocking of striped bass, or predator control might be effective at reducing predation.

Predation on juvenile salmonids

Juvenile chinook salmon were found by Thomas (1967) to be a major food item in the diet of striped bass in the spring and early summer during smolt outmigration through the Sacramento and San Joaquin rivers and Delta. Sacramento pikeminnow and juvenile steelhead may also be important predators of juvenile salmonids in some areas (Delta Fish Facilities Technical Coordinating Committee 1980, Pickard et al. 1982, USBR 1983). Man-made structures such as marinas, water diversion structures, bridge crossings, and rip-rap banks in the area may increase the abundance and predation success of ambush predators such as largemouth and smallmouth bass and the more piscivorous of the sunfish species (*Lepomis* and *Pomoxis* spp).

Predation may have the greatest impact on salmon populations when juveniles and smolts outmigrate in large concentrations during the spring through the lower mainstems of rivers and estuaries on their way to the ocean (Mather 1998). Density-dependent predation can occur if (1) predaceous fish switch prey to feed on outmigrating smolts when they occur at high densities, and/or (2) predators aggregate in response to local increases in prey density. Predator responses can be functional (predators eat more prey as prey density increases) or numerical (predator numbers increase through immigration or reproduction) (Sinclair et al. 1998). In a report on predation on chinook salmon in the Sacramento River, it was noted that pikeminnow tended to be drawn to and remain in areas where prey congregated, but striped bass fed on prey they encountered as they moved about and did not remain in an area once they had fed (USBR 1983). Pickard et al. (1982) suggested that striped bass may forage in roving schools and are opportunistic predators that may occasionally take advantage of a clumped food source.

The potential for predation is highest when habitats of juvenile and smolt salmonids overlap with preferred habitats of predaceous fish (e.g., during the earlier rearing period, juvenile chinook may tend to be found in lower-velocity nearshore areas used by smallmouth bass [Tabor et al. 1993, Curet 1993], while during smolt outmigration they may travel further from shore and be more vulnerable to predation by striped bass and pikeminnow). If striped bass exhibit a tendency to feed in schools in open water areas utilized by outmigrating chinook salmon smolts, they may show a stronger functional response to smolt outmigration and exert stronger predation pressure than ambush predators such as largemouth and smallmouth bass that may wander less widely and orient themselves to banks and in-water structures.

Tuolumne River Predation Studies

Predation by introduced largemouth and smallmouth bass is considered to be one of the primary factors limiting the survival of juvenile chinook salmon in the lower Tuolumne River. In 1990, the population of largemouth bass in the Tuolumne was estimated to be approximately 10,000 fish. Predation rates on juvenile chinook during a May pulse flow were as high as 1.6 salmon per predator per day. Combined, these values yielded predation rates for the largemouth bass population of approximately 8,000 to 14,000 salmon per day during the pulse flow period (TID/MID 1992). Maximum estimated predation rates were 3.62–5.31 salmon per predator per day for smallmouth bass in large deep pools during a pulse flow when chinook salmon were actively outmigrating (TID/MID 1992).

In 1989 and 1990, Modesto and Turlock Irrigation Districts conducted predation studies in the Tuolumne River. Stomachs of several potentially piscivorous fish species were sampled to evaluate which were important predators of juvenile chinook salmon and to estimate predation rates on juvenile salmon. Fish species sampled included Sacramento pikeminnow, white catfish (*Ictalurus catus*), channel catfish, warmouth, green sunfish, bluegill (*L. macrochirus*), sculpins (*Cottus* spp.), rainbow trout, and coho salmon (*O. kisutch*). Of all the species sampled, largemouth and smallmouth bass were determined to be the most important in terms of salmon predation (TID/MID 1992). Of all the species sampled, largemouth and smallmouth bass were determined to be the most important in terms of salmon predation (TID/MID 1992).

Sacramento and San Joaquin rivers/Delta Predation Studies

Limited information is available to characterize patterns and magnitude of predation on juvenile salmonids occurring in the Central Valley and Delta. Although studies have been conducted in Clifton Court Forebay to evaluate predation on juvenile chinook salmon, Gingras and McGee (1997, p. 13) stated that "… predation at Clifton Court Forebay has not been thoroughly modeled…". Mortality rates for salmon smolts in the Forebay, as estimated by mark/recapture experiments conducted at intervals from 1976 through 1993, were observed to range from 63% to 99%, with most mortality widely assumed to be due to predation by striped bass (Gingras 1997).

Studies conducted within San Joaquin River tributaries (Demko et al. 1998, TID/MID 1992) have shown that predation by species such as striped bass, smallmouth bass, and largemouth bass is a significant factor affecting chinook salmon smolt survival. Results of coded-wire tag mark-recapture studies with releases occurring in San Joaquin River tributaries have consistently shown a pattern of substantial mortality on juvenile fall-run chinook salmon during outmigration

(Hanson 2000). Although not directly quantified, the high mortality rates observed in many of these studies are consistent with predation-related mortality (Hanson 2000).

Striped bass are a top predator in the Delta. Average populations of 1.7 million adults during the late 1960s to early 1970s and 1.25 million adults during 1967-1991 (USFWS 1995) likely exerted considerable predation pressure on outmigrating juvenile salmon (Yoshiyama et al. 1998). Striped bass are considered to be a primary cause of juvenile salmon mortality at the state water-export facility in the south delta (USFWS 1995, as cited by Yoshiyama et al. 1998). Yoshiyama et al. (1998) noted that "[S]uch heavy predation, if it extends over large portions of the Delta and lower rivers, may call into question current plans to restore striped bass to the high population levels of previous decades, particularly if the numerical restoration goal for striped bass (2.5 to 3 million adults; USFWS 1995; CALFED 1997) is more than double the number of all naturally produced Central Valley chinook salmon (990,000 adults, all runs combined; USFWS 1995)." Striped bass are also known to favor splittail as food (USFWS 1999). Many of these species coexisted for decades in the Sacramento-San Joaquin Delta at much higher population levels than are now present; it remains unknown how recent declines in some populations of fish species have affected food-web relationships.

Juvenile striped bass are found year-round in large numbers above San Francisco Bay and apparently have no well-defined migration patterns (Thomas 1967). In contrast, adult striped bass follow well-defined migration patterns, with adults dispersing throughout the Delta and its tributaries in the spring to spawn. After spawning, adults return to the lower bays and adjacent coastal areas for the summer (Thomas 1967). Thomas (1967) carried out an extensive study of adult and juvenile striped bass food habits in the Sacramento and San Joaquin rivers upstream of the Delta and downstream to San Francisco Bay from 1957 to 1961. Striped bass become piscivorous at about 150 mm fork length, which they attain at about one year of age (Stevens 1966). Fish become important in the diet of juveniles with fork lengths from 130 to 350 mm, especially late in the summer when young-of-the-year striped bass and shad become available (Moyle 1976).

During the spring sampling period (from March 1 to May 31), Thomas (1967) found that fingerling chinook occurred in 22% of all striped bass stomachs and accounted for 9% by volume of all food consumed by 56 striped bass of all three size groups sampled in the lower Sacramento River area, and 17% by volume of 127 bass sampled in the area from Crockett to Pittsburg. Chinook salmon comprised 60% by volume of all food consumed by 144 bass in the lower Sacramento River from June 1 to August 31. Stevens (1966) noted that this study took place before 1962, prior to threadfin shad becoming an abundant food item for striped bass in the Delta. Stevens (1966) conducted an analysis of 8,628 striped bass stomachs collected from September 1963 through August 1964 in eight types of Delta environments. Subadult striped bass consumed chinook salmon in the spring, with salmon occurring at 4% frequency and 10% volume; adult striped bass also consumed chinook salmon during spring, but at a lower frequency and volume (Stevens 1966).

Predators may not have as great an impact on outmigrating juvenile salmonids in shallow unvegetated mud and sand habitats, compared to habitats where aquatic and/or emergent vegetation is present (Grimaldo et al. 2000). Rip-rap habitat in the Delta appears to be dominated by bluegill and largemouth bass (Chotkowski 1999), which are known predators of juvenile chinook salmon. Although there have been many efforts to address predation on outmigrating salmon in the Delta, there has not been a focused effort to address the role of habitat on predation dynamics during peak outmigration periods.

Management concerns

Recent concerns about the survival of endangered winter-run chinook salmon in the Sacramento River have focused on the impacts of striped bass predation on outmigrants and the effects of striped bass population enhancement on winter-run chinook population viability (Lindley and Mohr 1998, CDFG 1999). It was estimated that at a population of 765,000 striped bass adults, 6% of Sacramento River winter chinook salmon outmigrants would be eaten each year. Population viability assessments indicated that, while striped bass predation contributes significantly to winter chinook salmon extinction risk, the population would still be at risk even in the absence of striped bass (Lindley and Mohr 1998). NMFS has issued incidental take permits for winter chinook salmon to California Department of Fish and Game (CDFG) for their striped bass management program through a habitat conservation plan (CDFG 1999). Our proposed study will address a key concern identified by CDFG (1999) in their biological opinion—the lack of information regarding potential functional responses of striped bass predation rates with increasing density of juvenile salmonids.

Two studies in the Delta are currently underway to address fish predation. A predator-prey dynamics study is being conducted in shallow water habitats by the California Department of Water Resources and the U. S. Bureau of Reclamation (Nobriga and Chotkowski 2001); these data are still being analyzed, but preliminary findings indicate that striped bass, largemouth bass, and channel catfish are the most important predators of juvenile salmon in these nearshore habitats (M. Nobriga, pers. comm., 2001). CDFG recently began a Delta resident shoreline fishes monitoring survey that includes a stomach sampling component (Michniuk 2001), but data are not yet available.

The Interagency Ecological Program (IEP) has developed planning directives for 2002 that include "overarching questions" that were chosen because they (1) are central to IEP's mission and the interests of its stakeholders and CALFED, (2) are timely, and (3) usually require the coordinated and sustained effort of a multidisciplinary team of investigators to resolve. IEP identified three overarching questions, one of which is "What factors affect abundance, distribution, and survival of migrating salmonids in the Delta?". Because the mechanisms associated with mortality on outmigrating juvenile salmonids in the Delta are poorly understood, the proposed study will address the extent that predation dynamics may affect salmon survival in Delta habitats during the period of peak outmigration.

CALFED's vision for the restoration of the Sacramento-San Joaquin Delta includes restoring over 100,000 acres of shallow-water or wetland marsh aquatic habitat within the Delta (CALFED 2000—Vol. II, ERPP). As a result, many restoration projects awarded by CALFED in past years, as well as current CALFED efforts, involve restoring or increasing emergent wetland, shallow-water, and floodplain habitats within the Delta. CALFED funded 16 projects last year that emphasized shallow-water tidal and freshwater marsh habitat, including floodplain restoration along Delta in-channel islands near Empire Tract, Frank's Track, Big Break, and Lower Sherman Lake and Suisun Marsh, as well as reaches of the Consumnes, Mokelumne, and

San Joaquin rivers. The effectiveness of such restoration efforts on the survival of outmigrating salmon is not well understood, however, particularly in the Delta.

A.2 Justification

The primary goal of this study is to assess predation dynamics on outmigrating salmon at two sites in the Delta Region Ecological Management Zone. We propose to investigate fish species composition, relative abundance of predator and prey fish, and food habits for several known predator species in different habitat types.

The following are the hypotheses and specific questions that will be addressed by this study and are shown conceptually in Figure 1:

Hypothesis 1: Consumption of salmon is not influenced by changes in their density during outmigration.

- Does the frequency of occurrence of salmon smolts in predator diets change over the spring outmigration period?
- Does the frequency and volume of salmon in predator diets increase in response to increases in density of outmigrating salmon?

Hypothesis 2: Consumption of salmon does not vary with habitat type.

- Does the relative abundance of predator species vary with habitat type?
- Does the frequency of occurrence of salmon smolts in predator diets vary with habitat type?

Hypothesis 3: Consumption of salmon does not vary between Sacramento River and San Joaquin River system locations.

A.3 Approach

In order to predict the potential impacts of predation on salmonid smolts, the relative numbers and sizes of predators and prey, functional response of predators, and predictability of salmon outmigration timing needs to be better understood (Mather 1998; Sinclair et al. 1998). To address these information gaps, this proposal combines traditional fishery methods, including food habit studies and catch-per-unit-effort surveys, with newer technologies, such as using radio-tagging to address predator site fidelity.

The approach will consist of weekly sampling of several habitat types at two locations in the Delta during the peak salmon outmigration period. Weekly sampling should result in the sampling of predators during periods of varying salmon density, with opportunistic sampling to take place during known periods of high salmon density. Sample sites will be located within the Delta in the lower Sacramento and San Joaquin rivers. Both sites are located downstream of areas where hatchery releases occur – hatchery releases will present an opportunity to sample during spatially and temporally predictable concentrations of juvenile salmon. Sites will not be located immediately adjacent to areas where hatchery or salvaged salmonids are released as the study is not intended to address predator responses to “naïve” or “stressed” prey.

Task 1. Project permitting

The project will comply with the federal Endangered Species Act (ESA) and the California Endangered Species Act (CESA). All ESA documentation and required incidental take permits will be obtained prior to project implementation.

Task 2. Food habit study

Task 2a. Project location and habitat selection

Selection of specific sampling locations and representative habitats that will be sampled will occur after permit approval and before initiating weekly sampling efforts in the first year. At each site, gear will be tested for suitability and ease of sampling.

Predation dynamics will be assessed at two Delta locations: (1) on the lower Sacramento River near Ida Island and Isleton, and (2) on the lower San Joaquin River near the confluence of the Old River. Both sites are located downstream of and near locations where the USFWS/IEP is conducting monitoring of salmonid smolts (Figure 2). The two sites also offer good access for field sampling and a variety of habitat types. We will determine exact site locations based on feasibility of sampling, availability of habitat types, and ease of live capture and stomach sampling of predators.

Delta Habitat Types

Tidal marshes were likely the most widespread habitat within the Delta under historical conditions (CALFED 2000). It has been estimated that over 300,000 acres of the Delta were composed of tidal wetlands in a mosaic of emergent vegetation, marsh habitats, and open-water lakes and ponds (Atwater and Belknap 1980, as cited in CALFED 2000). These habitats, which are likely highly productive habitats for both predator and prey species, will be the focus of the sampling efforts proposed here. Habitats used by juvenile salmonids for rearing prior to their final outmigration to the sea include tidal and non-tidal freshwater marshes and other shallow water areas in the Delta. Few empirical studies have been conducted of the use of tidal marsh habitat by juvenile chinook salmon in the Delta, but it is assumed that these fish are strongly dependent on such habitat (Cannon 1999). Chinook salmon have also been captured over unvegetated mud and sand substrates (Chotkowski 1999). Large pool habitats have been observed to provide optimal habitat for introduced piscivorous fish in upstream river areas (TID/MID 1991) and may support similar populations in deep-water pools of the Delta. Scour holes, along with other open-water deep habitats, do not provide enough cover or prey to be preferred habitat for rearing salmonids, but are important because smolts must migrate through these habitats on their way to the sea.

Sampling efforts will be stratified by habitat type. Four habitat types will be sampled, although all four types may not be present at each site. The four habitat types include man-made habitats (e.g., rip-rap, pilings), natural shallow water habitats (e.g., bars, tules), low-velocity backwater habitats (e.g., sloughs), and deep water (e.g., scour holes, open deep water). It may be necessary to modify our sampling stratification based on conditions encountered in the field. Therefore, after initial field reconnaissance and sampling, we may engage in further consultation with permitting agencies and senior project scientists to revise our sampling design. Regardless of the final design, we plan to sample a variety of habitat types in a stratified manner using sampling equipment that is most appropriate for capturing predaceous fish.

Existing salmonid monitoring programs

Existing efforts targeted at monitoring juvenile salmon abundance will provide information on seasonal changes in abundance within the Sacramento and San Joaquin rivers. This information will be combined with our field sampling efforts to provide an indicator of relative abundance of juvenile salmon. This component of the study will involve sampling two sites during the peak outmigration months of April and May for two years. During these months, several agencies, including CDFG, U.S. Fish and Wildlife Service, and the Interagency Ecological Program (IEP), are conducting monitoring of juvenile salmonids and other fish at several locations on the Sacramento and San Joaquin rivers, and in the Delta.

These sampling programs use at least two methods to capture juvenile salmon: (1) beach seining surveys to estimate the relative inter- and intra-annual abundance and distribution of all races of salmonid juveniles, and (2) midwater and Kodiak trawling to sample juvenile salmon and estimate relative abundance and timing of fry and smolts entering the Delta. Locations of some of the existing monitoring sites are provided in Figure 2.

Some of the monitoring results are being used to modify Delta operations, including setting instream flows in tributaries, the timing of installation of the barrier at the head of Old River, and the levels of export of water from the State and Federal pumping facilities. We anticipate using this monitoring data, along with information on the timing and location of hatchery releases, to provide information on the relative abundance of juvenile salmonids as they outmigrate through the Sacramento and San Joaquin rivers and Delta.

<u>Task 2b. Weekly predator sampling for food habits</u>
At the two sites, a crew of three people will conduct weekly sampling in April and May of predators and their food habits. Primary methods used will include the use of boat electrofishing, stationary multi-mesh gill nets, large fyke traps, and hook-and-line sampling. Each method has risks associated with potential incidental capture of threatened or endangered species, and each method has potential sampling bias for species and sizes of predators as well as potential for causing predators to regurgitate stomach contents. Predators will be captured alive and gastric lavage will be used to evacuate stomachs to determine species and sizes of prey, and consumption rates on salmonids and other prey. Sampling will occur after dawn, when it is most likely that piscivorous predators have full stomachs (Tabor et al. 1993). Catch-per-unit-effort will be determined as an estimate of relative abundance of predators and prey. Gill net mesh sizes will be greater than 4 inches stretch, in order to capture larger sized predators, and should be large enough to minimize or avoid capture of juvenile salmonids or splittail (Randy Baxter, pers. comm., 2001). Gill net sets will be of short duration (<1 hr) to capture predators alive and with stomach contents intact; thus, any incidental catch of other species, particularly splittail, is not likely to result in mortality. In addition, the sample sites are located upstream of areas where delta smelt tend to occur in order to minimize or eliminate potential for affecting this species.

Each gear type will be used in specific habitat types and in a manner that will be most effective in capturing the target species. For example, electrofishing will be conducted in shallower waters with lower velocities where it is likely to be most effective. Gill nets can be fished in deeper waters such as channels, and holes or pools where larger predators and stronger currents may be encountered. Fyke nets will be fished for longer time periods, along river banks or in channels, where fish in transit may be concentrated and captured. Hook-and-line sampling will be used opportunistically in a variety of habitat conditions, particularly to locate predator aggregations. If practical, this sampling gear would then be replaced with a more effective gear type that is likely to have a higher CPUE, and to be more cost-effective. Because electrofishing will provide an estimate of relative abundance of prey for different habitats, sampling of deeper areas that cannot be electrofished will not result in estimates of relative prey abundance independent of predator food habits.

Water temperature and clarity (Secchi disk) will be measured at each site during field sampling.

Task 2c. Opportunistic predator sampling for food habits

Opportunistic sampling will be conducted when there is evidence that outmigrating salmon are abundant, based on upstream hatchery releases, ongoing agency monitoring of juvenile salmon abundance, and flow releases or other operational modifications. At each site, two crews of three people each will conduct at least two additional sampling efforts (in addition to weekly sampling), each consisting of periodic sampling in the day and night for 24 to 48 hours, to determine if there are diurnal patterns in predator assemblages, predator food habits, and habitat utilization. Catch-per-unit-effort will be determined as an estimate of relative abundance of predators. Sampling methods during opportunistic sampling will be the same as described above for weekly sampling.

Task 2d. Analysis of stomach contents

Stomach contents will be removed using gastric lavage, preserved in the field, and analyzed in the laboratory (Foster 1977, Light et al. 1983). Species, sizes, volumes, and weight of stomach contents will be determined. The frequency of occurrence and percent volume of juvenile salmonids as a component of the diet will be determined for each predator species sampled. Hatchery-reared salmonid juveniles with coded wire tags (CWT) are likely to be present in the study area. All CWTs will be retained and made available to the respective agencies for identification purposes. Identification results will be included in our database and analyzed.

Task 3. Predator tracking: predator site fidelity

When predators are captured and their stomachs evacuated (see above), they will be tagged with either a Floy or radio tag. Externally placed Floy tags will enable predators to be uniquely identified and will provide a mark-recapture estimate of relative predator abundance at the sample locations. These data will also allow us to determine if individual predators consistently feed at sampling sites.

In addition to tagging predators with Floy tags, ten individual predators (likely striped bass) will be selected at each site and surgically implanted with radio tags. Coded low-frequency tags will be used to maximize detections of individually marked predators for the duration of the study. Sampling locations will be located in shallow (<5 m [16.4 ft]) water with moderate conductivities; therefore, signal strength should be strong. Signals will be received with both continual data recording stations at the sample sites, and with manual tracking. Each station will be outfitted with an antenna connected to a receiver that detects signals 24 hours a day. Each detection, along with location, date, and time, will be recorded with a continuous data logger. Information will be downloaded from the data logger during each sampling visit and stored in a centralized computer database. These data will be used to determine fidelity of individual predators to specific sites to address the degree to which predators either move into areas with high smolt densities or remain at sites regardless of smolt presence or density. Manual tracking will be conducted opportunistically during field sampling to supplement data obtained from continuous data recording. Individual predators will be tracked from a boat and/or from land using an antenna and mobile receiver connected to headphones monitored by a researcher.

These data will allow the movements of individual predators to be tracked opportunistically to further address site fidelity of predators, and lead to a more comprehensive understanding of predator habitat use and behavior.

Task 4. Data entry, QA/QC, and analysis
Data entry and QA/QC will be conducted as described in A.6. Microsoft Access will be used as the database software. Microsoft Access Data analysis will include determining relative abundances (CPUE) of predator and prey species taken during field sampling associated with each habitat type. Frequency of occurrence and volume of prey species for each predator in each habitat type will also be determined. Appropriate statistical analyses will be chosen based on the data required for testing of hypotheses.

Task 5. Reports and presentations
One report for each of the two years of field sampling will be prepared for the IEP newsletter. Draft and final reports will be prepared and provided to CALFED. The draft report will be made available for review by the permitting agencies and IEP prior to completion of the final report. The final report will be in a form that can be readily submitted for publication in a peer-reviewed journal such as the Canadian Journal of Fisheries and Aquatic Sciences or the Transactions of the American Fisheries Society.

Presentations documenting the results of the study will be provided at appropriate CALFED or IEP symposia or workshops, at least one per year.

A.4 Feasibility

This project is feasible and complementary to ongoing predation studies, salmon survival monitoring, and habitat restoration efforts in the Delta. The methods chosen have been proven effective for assessing predators and their food habits. The project is contingent on obtaining scientific collecting and incidental take permits for listed species from USFWS, NMFS, and CDFG. Although take may occur, this study should provide useful information to resource agencies for decision-making regarding stocking of predaceous fish and habitat restoration in the Delta. Sampling locations, timing of sampling, and gear types used will be chosen to minimize or avoid take of listed fish species.

A.5 Performance Measures

Performance measures for the study will be developed in coordination with the senior project scientists and permitting agencies as part of project permitting (Task 1) and initial site and habitat selection (Task 2a). Measures will likely include statistically reliable estimates of relative abundance (catch-per-unit-effort) of predators and prey for all habitat types selected in order to be able to test hypotheses.

A.6 Data Handling and Storage

This project will result in the collection and development of data and information over a 3-year period. All data collected will undergo standard Stillwater Sciences QA/QC procedures before original data are archived. This process includes review of field notes and data by field crew personnel, review and check of data entry by an unassociated person to ensure accuracy, and creation of working and backup copies of original data sheets to eliminate possible loss or tampering of original data. All data will be archived at Stillwater Sciences. Back-up copies of electronic data will also be maintained off-site as part of Stillwater Sciences' standard back-up procedures.

A.7 Expected Products/Outcomes

The following products are expected outcomes of the tasks outlined above:

Task	Expected Product/Outcomes
TASK 1: PROJECT PERMITTING	
	• NMFS, USFWS, and CDFG collecting permit/ESA permit application and filing.
TASK 2: FOOD HABIT STUDY	
2A	• Project location and habitat selection based on initial sampling with concurrence of the agencies and senior project scientists.
2B	• Conduct weekly predator sampling for food habits
2C	• Conduct opportunistic predator sampling for food habits
2D	• Conduct analysis of stomach contents
TASK 3: PREDATOR TRACKING: PREDATOR SITE FIDELITY	
	• Tag select predators for monitoring over 2-year period for site fidelity
TASK 4: DATA ENTRY, QA/QC, AND ANALYSIS	
	• Data entry and QA/QC • Statistical analysis comparing relative abundance of predators and prey and food habits associated with the two locations and habitat types in the Delta.
TASK 5: REPORTS AND PRESENTATIONS	
	• Two IEP newsletter submissions, one per year • Quarterly IEP reports • Presentations at IEP/CALFED symposia/workshops, one per year • Draft Report • Final Report

A.8 Work Schedule

We anticipate completing Tasks 1 through 3 within the first two springs of the 3-year contract period. Task 4 will be completed in year 3 following completion of the field sampling. If Task 1 (permitting) delays initiation of Tasks 2 and 3, the work schedule will be adjusted accordingly. Specific details of the work schedule are provided in Figure 3.

B. APPLICABILITY TO CALFED ERP AND SCIENCE PROGRAMS GOALS AND IMPLEMENTATION PLAN AND CVPIA PRIORITIES

B.1 ERP, Science Program and CVPIA Priorities

The anticipated outcomes of the proposed project support many of the goals of the ERP, Science Program, and CVPIA as well as specific restoration priorities for the Delta Region outlined by CALFED's Draft Stage 1 Implementation Plan. Specific project support of individual goals and priorities are indicated below with parentheses.

The proposed project will assess the role of predation dynamics on outmigrating salmon in the Delta. The project will also develop a conceptual understanding of the spatial and temporal linkages shaping these interactions. A better understanding of predator and prey dynamics in

Delta habitats is critical for developing effective restoration and salmon recovery strategies and to advance our baseline understanding of ecological processes in the Delta (ERP Strategic Goal 2, MR-6, DR-4, and Science Program goals).

Predator abundance in various habitat types will also be assessed through the proposed project. With a marked increase in habitat restoration projects funded within the Delta, this project will provide us with a critical tool to help evaluate the potential success of restoration measures for both target and non-target, non-native species (ERP Strategic Goals 4 and 5; DR-1, DR-2, DR-6). For example, an important component of shallow water restoration in the Delta is an understanding of the impacts of increasing suitable habitat for at-risk species, such as chinook salmon, and predaceous, non-native species, such as largemouth bass.

An understanding of the temporal overlap of potential predators and prey within the Delta is critical to the proposed project, by complementing existing data and monitoring programs with focused studies and sampling (Science Program Goals). Understanding the temporal component of these processes will also help to ensure that fishery and water management actions will be effective.

The proposed project will also provide information on the importance of non-native predator species in the Delta and their potential impact on outmigrating salmon. This understanding will allow CALFED and other regulatory agencies to more effectively implement actions to reduce impacts of introduced predators on native species (MR-1, DR-5), and to provide baseline information on the potential physical and biological processes that may affect salmonid survival in the Delta (Science Program and CVPIA goals).

B.2 Relationship to Other Ecosystem Restoration Projects

This proposed project relates to many projects, plans, and studies currently being implemented or planned that share this project's overarching goal of better understanding the mechanisms associated with mortality of outmigrating salmon in the Delta. Implementation of the proposed study, in combination with other related restoration and research efforts in the Delta, presents an opportunity to improve understanding of the mechanisms associated with mortality of outmigrating salmon in Delta habitats that can help prioritize habitat restoration efforts. The projects listed below represent examples of the many projects which relate directly to the focus areas of this study: (1) salmonid predation dynamics, (2) salmonid survival, and (3) salmonid habitat assessment and enhancement in the Delta.

CALFED project #2001-B201, the Tuolumne River Restoration: Special Run – Pool 10 project shares the proposed project's goal of understanding the dynamics of, and decreasing the potential for, predation on salmonids in the Delta and its tributaries. The existence of large in-channel gravel mining pits provides optimal habitat for many non-native predatory fish such as largemouth bass. The objectives of the Special Run – Pool 10 project are to improve salmon spawning and rearing habitats and reduce potential predator habitat by (1) filling the in-channel mining pits, (2) preventing future connections between the river and off-channel mining pit, (3) restoring native riparian habitats, and (4) allowing the river channel to migrate within the restored floodplain.

The following projects are completed or ongoing projects that would complement the efforts of the proposed project to study factors affecting salmonid survival in the Delta and its major tributaries.

- The Juvenile Salmon Migratory Behavior Study in North, Central and South Delta (CALFED #2001-K217) will improve understanding of juvenile anadromous salmonid migratory behavior in the Delta to guide ongoing and future Delta ecosystem restoration efforts as well as water conveyance options. Information generated from this investigation will help determine if salmonid outmigration is influenced more by the net movement of flow toward the south Delta pumps or by tidal flows and will identify important parameters affecting juvenile salmon migration.
- The goal of the Calaveras River Chinook Salmon and Steelhead Population Abundance and Limiting Factors Analysis (CVPIA #2001-K219) is to provide information to be used in the development of a technically sound, consensus-based plan to restore self-sustaining populations of chinook salmon and steelhead to the Calaveras River. The proposed project will aid the consensus-building process by providing scientifically defensible, quantitative information to prioritize restoration and improve management of the physical factors that affect the dynamics of chinook salmon and steelhead populations.
- The Health Monitoring of Hatchery and Natural Fall-run Chinook in the San Joaquin River project, sponsored by the USFWS, supplements fish health investigations being conducted within the Sacramento River basin with comparative information from the San Joaquin River basin. The proposed project will complement this effort by collecting additional data on the health of hatchery and wild smolts and on potential differences in survival between hatchery and wild salmonids.

The following projects represent just a few of the efforts to evaluate and restore salmonid habitat in the Delta and its tributaries. The success of these efforts will be determined in part by the use of the restored habitat by salmonids. How habitat restoration efforts affect chinook salmon and other native and non-native species is not fully understood. By investigating habitat-specific predation dynamics on salmon smolt in the Delta, the proposed project should provide valuable information for evaluating the success and merit of these habitat restoration efforts.

- The goal of Understanding Tidal Marsh Processes and Patterns project (B169/ERP-99-B13) is to predict the ecological benefits of restoring shallow-water tidal habitat in the Bay-Delta. This project will provide data for resolving uncertainties related to restoring tidally influenced habitats, and assessing the role of wetland habitat in production of dissolved organic carbon to the ecosystem.
- Phase II Demonstration Project for the Protection and Enhancement of Delta In-Channel Islands (ERP-01-N13) seeks to enhance Delta island habitat to provide important tidal wetlands for a wide variety of fish, wildlife, and plant species. The project seeks to demonstrate that the erosion of in-channel islands can be slowed, stopped, or reversed using biotechnical erosion control methods (erosion control using naturally-occurring organic material), and that biotechnical erosion control methods can benefit important or high-priority fish, wildlife, and plant species.
- Non-Structural Alternative at the San Joaquin River National Wildlife Refuge: Refinement for Habitat Enhancement (CVPIA #2001-D202) is a demonstration channel-floodplain reconstruction project that will modify levees to reconnect the mainstem San Joaquin River with floodplain lands at the refuge near the mouth of the Tuolumne River. The objectives of the

project are to improve rearing conditions for juvenile salmonids, minimize the potential for stranding of fish, and enhance San Joaquin River food-web productivity.

- In 1997, CALFED funded the Liberty Island Acquisition and Restoration Phase I project (99-B165/ERP-00-F06) to acquire two inholdings on the island and develop a restoration and monitoring plan. Restoration of the island will increase tidal shallow-water, tidal emergent wetland, seasonal wetland, delta slough, and riparian habitats to benefit Delta smelt, winter-run chinook salmon, and other high-priority species.
- The East Delta Habitat Corridor project (ERP-99-N03) is a tidal marsh and riparian restoration project to improve habitat conditions along 14 miles of Georgiana Slough. Habitat enhancement in Georgiana Slough is a high priority for improving survival of juvenile chinook salmon.

B.3 Requests for Next-Phase Funding

N/A

B.4 Previous Recipients of CALFED Program or CVPIA Funding

See Table 1 for information regarding projects previously funded by the CALFED Program or CVPIA funding.

B.5 System-wide Ecosystem Benefits

Implementation of the proposed project will produce fundamental technical information necessary for better understanding predation on outmigrating salmon smolts in Delta habitats. Since all salmonids produced in the Sacramento and San Joaquin river tributaries must migrate through the Delta, this project is compatible with all programs striving to enhance salmonid production and survival. The project should help guide ongoing and future habitat restoration and enhancement efforts in the Delta. The project should also complement other studies of Delta survival (VAMP, Delta Cross Channel studies), as well as provide information to resource managers that may be useful for reducing predation by non-native fish species on juvenile salmonids.

B.6 Additional Information for Proposals Containing Land Acquisition

N/A

C. QUALIFICATIONS

The Project Team consists of Stillwater Sciences, Hanson Environmental, Inc., National Marine Fisheries Service (NMFS), and the U.S. Environmental Protection Agency (EPA). Stillwater Sciences will act as lead, and will conduct all field investigations with their subconsultant Hanson Environmental, Inc. Drs. Steve Lindley (NMFS) and Bruce Herbold (EPA) will serve as senior project scientists. Stillwater Sciences will complete all environmental documentation and permitting, and will develop and draft the study and monitoring plans. Stillwater Sciences will be the CALFED contractee and project manager and will be responsible for payments, reporting, and accounting.

The lead management team will consist of Craig Fixler (Stillwater Sciences, Berkeley), Sharon Kramer (Stillwater Sciences, Arcata), and Scott Wilcox (Stillwater Sciences, Davis). Team leaders will be supported by staff members that have extensive scientific expertise in the Sacramento/San Joaquin basins.

Stillwater Sciences: Stillwater Sciences is a firm of biological, ecological, and geological scientists. The company specializes in developing and implementing new scientific approaches and technologies for problem-solving in aquatic and terrestrial systems and has extensive experience and in-house capabilities in applying GIS to environmental analyses. Its founding members have extensive experience in freshwater ecology and fluvial geomorphology. Recent projects have included impact assessment and enhancement of watersheds affected by hydroelectric dams, timber harvest, and irrigation in California and the Pacific Northwest.

Mr. Frank Ligon is an aquatic ecologist and geomorphologist with over 20 years of experience in examining the role of fluvial processes and morphology in the ecology of stream fish, invertebrates, and plant communities. He has successfully managed several complex, long-term projects involving watershed analysis, salmon ecology and restoration, geomorphology, and riverine ecosystem restoration. His Central Valley experience includes managing a ten-year chinook salmon ecology and restoration project on the Tuolumne River below New Don Pedro Dam.

Dr. Sharon Kramer has over 20 years of experience in aquatic ecology and fisheries biology in the Pacific Northwest, California, Australia, and Hawaii. She has been involved in technical teams with academics, resource agencies, and environmental groups under the Interagency Ecological Program (IEP) of CALFED. She provided expertise in modeling, and assessing restoration actions and impacts of water supply operations in the Delta, as well as providing technical expertise on a variety of IEP project work teams. Her broad background in Central Valley and Sacramento-San Joaquin Delta fisheries issues provided much of the technical expertise for the CALFED White Paper assessing the effects of diversion on fish populations in the Sacramento-San Joaquin Delta. Dr. Kramer also has extensive experience investigating water supply and diversion impacts on aquatic species and their habitats. She was a scientist involved in implementing the Bay-Delta Accord and worked as a Resource Specialist for the Metropolitan Water District of Southern California in Sacramento in the early stages of CALFED in 1996. She has extensive research experience in freshwater, estuarine, and marine ecology.

Scott Wilcox is a project manager and fisheries biologist with 20 years of experience in water resource investigations that emphasize water resource development and operation analyses. His experience includes extensive work in conducting habitat and impact assessments for various salmonids and native fish assemblages, including fish population analyses, IFIM studies, macroinvertebrate surveys, and entrainment studies. He has managed or personally conducted aquatic resource studies for hydroelectric re-licensing for over 25 projects. As part of his aquatic resource work, Mr. Wilcox has provided technical and regulatory expertise in evaluating impacts to endangered species. He has been a project manager for more than a dozen projects, including several habitat enhancement projects in the Sacramento-San Joaquin Delta. Mr. Wilcox is the project manager for the Napa River Fisheries Program, a five-year effort to monitor the success of the U.S. Army Corp of Engineers Napa River Project. The Napa River Project will reconnect nearly seven miles of the lower Napa River to its floodplain to provide flood protection while creating wetlands, removing dikes, relocating bridges, and modifying channels, levees, floodwalls, and pump stations. The Napa River Fish Monitoring Plan, an integral part of the Napa River Project, will evaluate the success of restoration efforts in providing habitat for native fish.

Dr. Peter Baker has ten years experience applying mathematics and statistics to address issues in aquatic ecology. Dr. Baker is currently working with CALFED to evaluate the effects of CALFED's ongoing restoration projects on population dynamics of key native fish species, including chinook salmon, Delta smelt and Sacramento splittail. Dr. Baker has prepared or assisted in the preparation of numerous reports on the chinook salmon of the Tuolumne River and Sacramento-San Joaquin River Delta of California, including FERC proceedings. He also prepared and presented expert witness testimony before the State Water Resources Control Board Bay-Delta Hearings. Dr. Baker is also responsible for maintening and redefining the EACH simulation model for San Joaquin chinook salmon populations, and has developed or assisted in developing numerous other salmonid population models in California and Montana. Dr. Baker has developed individual-based models of spawning habitat usage by salmonids, and has extended PHABSIM modeling of chinook salmon habitat in the Tuolumne River to include water temperature considerations. He is the principal author of a publication on the relationship between water temperature and salmon smolt survival in the Sacramento-San Joaquin Delta (Baker et al. 1995).

Craig Fixler brings over 20 years of business management experience in technology, construction and development, and environmental services with companies including Viacom, Electronic Data Systems, and EA Engineering, Science, and Technology. At EA, Mr. Fixler was business manager for a staff of 250 people. In this role, he supervised progress and completion for more than 100 projects, reviewed contracts and proposals, and coordinated marketing activities. He held the position of Chief Financial Officer at StarQuest Software, Bardon Data Systems, and Electrical Power Products, and was principal owner of Kansky Development Company and The Elms of Sunnyvale, LLC.

Dr. Bruce Orr has over 20 years of experience in studying the population and community ecology of aquatic, terrestrial, and fresh- and saltwater wetlands in California and other western states. During the past five years, Dr. Orr has managed a variety of complex, multi-year projects focusing on the use of watershed analysis and ecosystem management approaches to meet a variety of regulatory needs, including TMDLs, state and federal Endangered Species Acts, and California Forest Practice Rules. He has expertise in watershed analysis, developing natural resource management plans, and analyzing effects of flow regimes and suspended sediment transport on fish populations and riparian vegetation.

Hanson Environmental Inc.:

Dr. Charles Hanson has over 25 years of experience in freshwater and marine biological studies. Dr. Hanson has contributed to the design, analysis and interpretation of fisheries, stream habitat, and stream flow studies for evaluating the effects of instream flows on salmonid spawning, production, and migration. Dr. Hanson has directed numerous investigations and environmental impact analyses for projects sited in freshwater, estuarine, and marine environments of the San Francisco Bay/Delta, the central and northern California coast, Puget

Sound, Hudson River, and Chesapeake Bay. Dr. Hanson has expertise in incidental take monitoring and endangered species investigations, developing recovery plans, ESA consultations, and preparing aquatic Habitat Conservation Plans. Dr. Hanson has also participated in developing adaptive management plans including real-time monitoring and management of power plant cooling water and other diversion operations, and the San Joaquin River Vernalis Adaptive Management Plan (VAMP).

Senior Project Scientists:
Senior project scientists are active participants in the project, from the proposal stage through field reconnaissance and discussions of field methods, to data interpretation and report review. Unlike peer-reviewers who provide input at the end of the project, senior project scientists provide ongoing support to ensure that the best possible science is used in the project. The senior project scientists for the proposed project are:

- Dr. Bruce Herbold (U.S. Environmental Protection Agency)
- Dr. Steve Lindley (National Marine Fisheries Service)

D. COST

D.1 Budget

See posted web forms and Attachment A for more information.

D.2 Cost-sharing

N/A

E. LOCAL INVOLVEMENT

Coordination with USFWS, IEP and Delta Operations/DWR are necessary to implement this project and determine appropriate timing for sampling. Additional coordination will occur with CDFG and NMFS on locations, methods and timing, and results.

F. COMPLIANCE WITH STANDARD TERMS AND CONDITIONS

The applicants have reviewed and are able to comply with the terms and conditions set forth in Attachments D and E of the Proposal Solicitation Package.

G. LITERATURE CITED

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Tables, Figures, and Attachments

Table 1. Previous Recipients of CALFED Program or CVPIA Funding

Project title	Program/Project Number	Current status	Project milestones
Stillwater Sciences previous CALFED Program funding			
Merced River Corridor Restoration Plan-Phase II	ERP/ Project #98E-09	complete	(1) social, institutional, and infra-structural opportunities and constraints to restoration analysis; (2) baseline evaluations of geomorphic and riparian vegetation conditions
Merced River Corridor Restoration Project-Phase III	ERP/Project #2000 E-05	in progress	development of (1) geomorphically functional channel and floodplain design guidelines; (2) the Merced River Corridor Restoration Plan; (3) conceptual designs for 5 top-priority restoration projects
A Mechanistic Approach to Riparian Restoration in the San Joaquin Basin	ERP/#99-B152	starting-up/in progress	(1) literature and existing data review; (2) development of conceptual model and study plan
CALFED Sacramento/San Joaquin Tributary Assessments	ERP/	complete	assessment protocol applied to the Tuolumne River and Deer and Clear creeks
Tuolumne River Coarse Sediment Management Plan	Service Agreement #010801		fine sediment report; EACH and stock recruitment modeling underway
M&T Ranch Pump Intake Assessment	Contract 01A120210D	complete	developed mitigating techniques for sediment burial of pump intake
Saeltzer Dam Removal Analysis	Contract B-81491	complete	(1) application of sediment transport model to a dam removal project; (2) pre- and post-dam removal channel monitoring
Hanson Environmental, Inc., previous CALFED funding			
Wilkins slough positive barrier fish screening evaluation	Subcontract through Reclamation District 108	still ongoing	
Salmonid White Paper	Subcontract to CH2MHill	still ongoing	
Feasibility Study for developing a positive barrier fish screen	Subcontract to Sutter Mutual Water Company	Still ongoing	
Feasibility Study for consolidation of three unscreened diversions	Subcontract to Sutter Mutual Water Company	still ongoing	
Princeton Diversion positive barrier fish screen	Subcontract to Reclamation District 1004	still ongoing	
Water quality in Rock Slough	Subcontract to Contra Costa Water District	still ongoing	
Stillwater Sciences previous CVPIA funding			
Merced River Corridor Restoration Plan-Phase I	AFRP/	complete	formation of the Merced River Stakeholder Group and Technical Advisory Committee
Merced River: Ratzlaff Project	AFRP/CVPIA	complete	provide comments on existing and

Project title	Program/Project Number	Current status	Project milestones
	11332-9-MO79		proposed restoration efforts; coordinate with Merced River Restoration Project
Stanislaus River: 2 Mile Bar	AFRP/CVPIA 11332-9-MO80	complete	prepare summary of restoration potential and strategies, focusing on geomorphic opportunities and constraints
Stanislaus River: Smolt Survival	AFRP/CVPIA 11332-0-MO09	complete	prepare assessment of coded wire tag and multiple mark-recovery smolt survival assessment programs
Calaveras River Spawning Habitat Evaluation	AFRP/	complete	conduct reconnaissance-level evaluation of steelhead and salmon habitat conditions and population dynamics
Calaveras Salmonid Limiting Factors Study	AFRP/CVPIA 11332-1-GO06	starting-up/in progress	reconnaissance surveys are underway

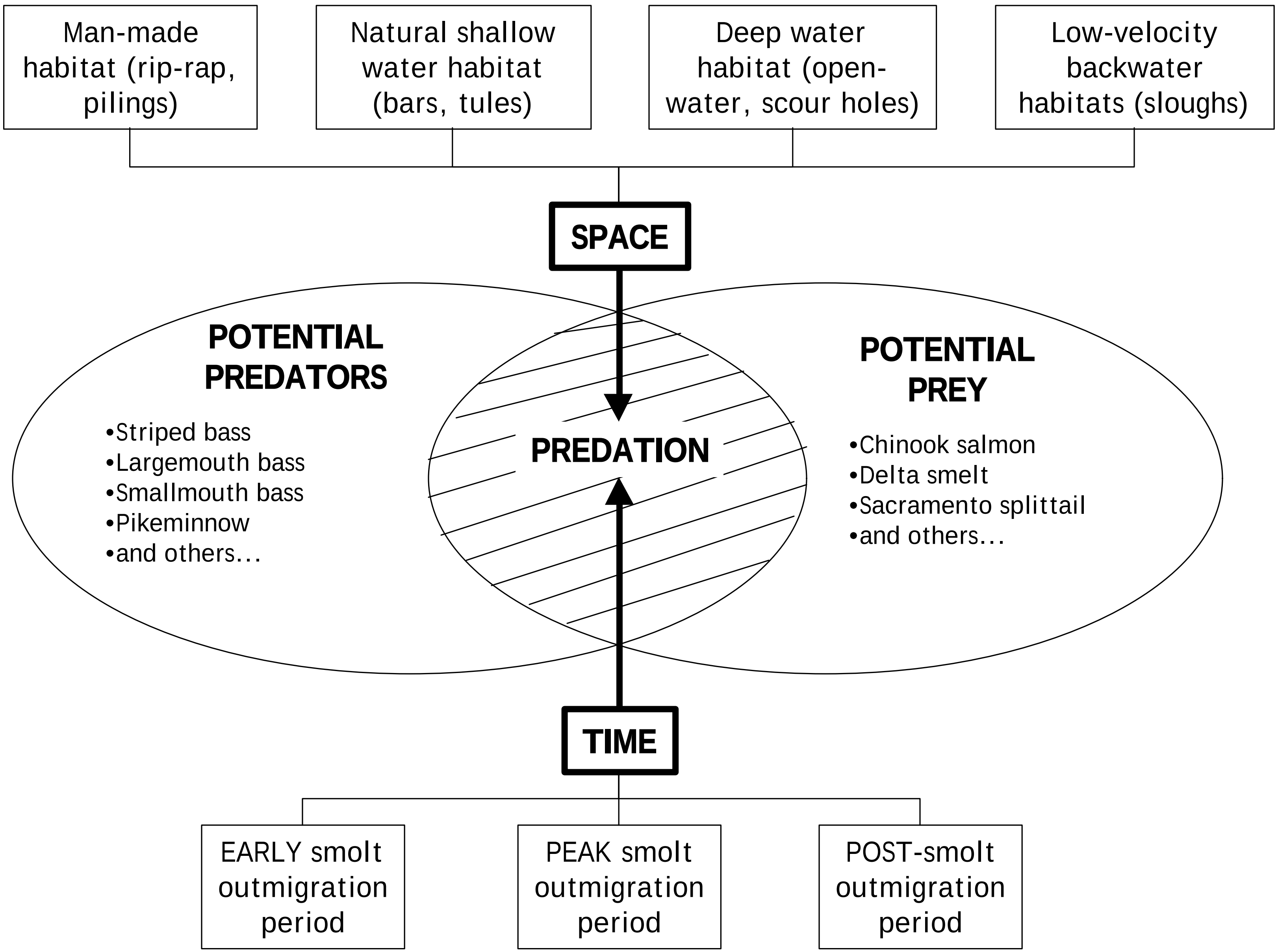

Figure 1. Conceptual model of approach for proposed project.

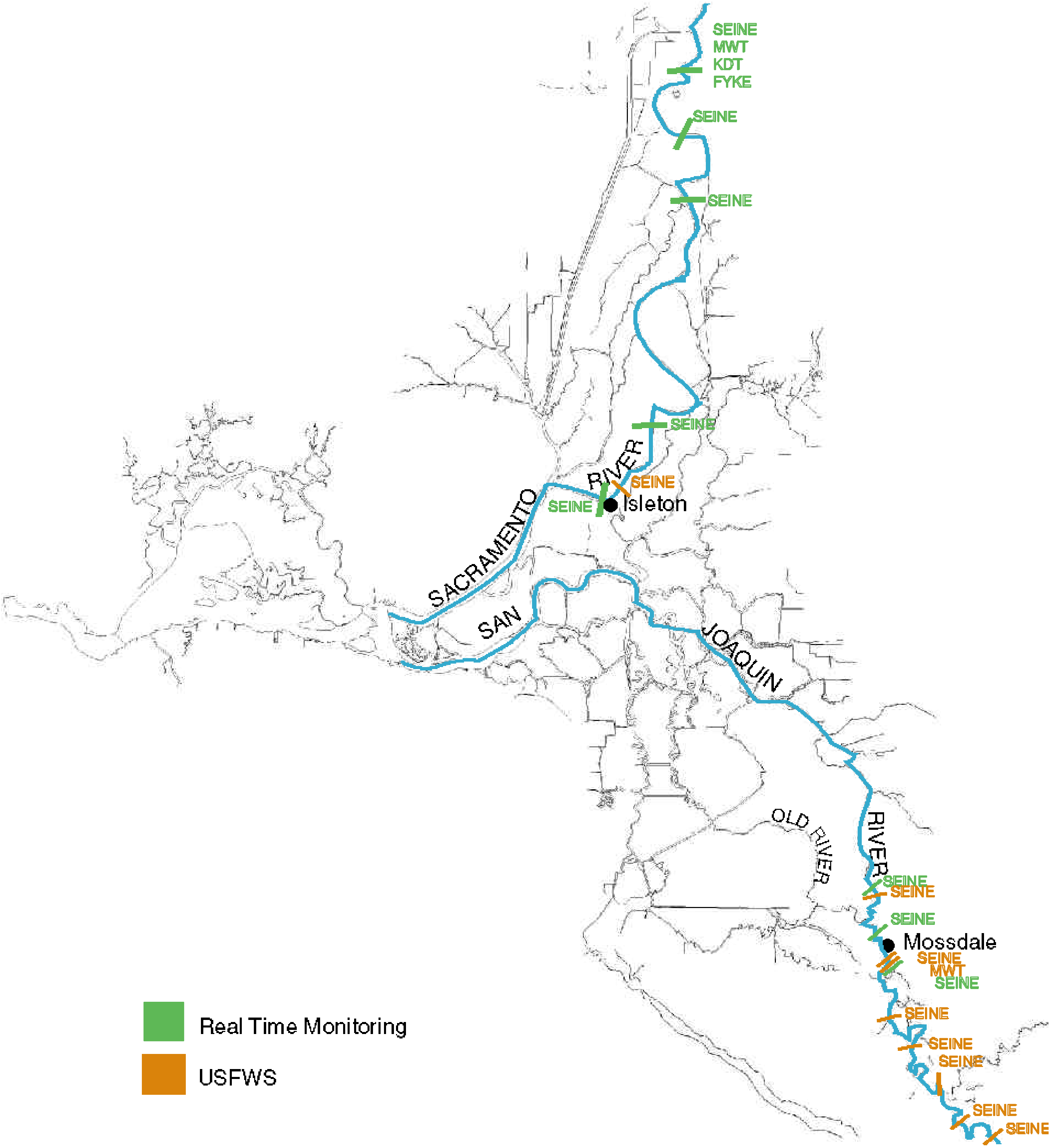

Figure 2. Current monitoring efforts upstream and near proposed sampling sites in the Sacramento-San Joaquin Delta, based on the Interagency Ecological Program's Real-time Monitoring program and the U.S. Fish and Wildlife's Young Chinook Salmon Program sample sites.

	2002			2003												2004												2005	
	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb
Task 1: Project Permitting																													
Scientific collection permits, ESA permits with NMFS, USFWS, CDFG	■	■	■	■	■	■																							
Task 2: Predator Food Habits																													
Task 2A: Project location and habitat selection						■																							
Task 2B: Weekly predator sampling for food habits							■	■											■	■									
Task 2C; Opportunistic sampling of predators for food habits during periods of high smolt abundance							■	■											■	■									
Task 2D: Labatory analysis of predator stomach contents collected at two field sites									■	■	■										■	■	■						
Task 3: Predator Tracking: Predator site fidelity																													
Tag and recapture of individual predators using external Floy Tags							■	■											■	■									
Tagging and manuel and stationary tracking of individual predators using surgically implanted radio tags							■	■											■	■									
Task 4: Data entry, QA/QC, and analysis																													
Data entry and QA/QC. Statistical analysis comparing relative abundance of predators and prey and food habits associated with the two locations and habitat types in the Delta.							■	■	■	■	■	■							■	■	■	■	■	■	■	■	■	■	
Task 5: Reports and Presentations																													
Quarterly IEP reports													■	■												■	■		
Draft report																											■	■	■
Final report																											■	■	■
Presentations at IEP/CalFed workshops/symposia															■	■	■	■	■	■	■	■	■	■	■	■	■	■	■

Figure 3. Work Schedule

Attachment A: Form VI Summary

Year 1

Year 1	Direct Labor Hours	Salary	Benefits	Travel	Supplies & Expendables	Services / Consultants	Equipment	Other Direct Costs	Total Direct Costs	Indirect Costs	Total Costs
Task 1. Project permitting	164	$ 5,802	$ 1,959	$ -	$ -	$ -	0	286	$ 8,048	$ 9,173	$ 17,221
Total cost Task 1 Year 1	**164**	**$ 5,802**	**$ 1,959**	**$ -**	**$ -**	**$ -**	**0**	**286**	**$ 8,048**	**$ 9,173**	**$ 17,221**
Task 2a. Project Location and Habitat Selection	349	$ 11,508	$ 3,886	$ 3,600	$ -	$ 1,586	2550	539	$ 23,669	$ 18,965	$ 42,634
Task 2b. Weekly predator sampling for food habits	1425	$ 67,533	$ 22,806	$ 36,000	$ 4,000	$ 5,703	33850	4897	$ 174,789	$ 114,880	$ 289,668
Task 2c. Opportunistic predator sampling for food habits	835	$ 40,918	$ 13,818	$ 18,000	$ 2,500	$ 5,411	4600	2614	$ 87,861	$ 67,801	$ 155,661
Task 2d. Analysis of stomach contents	307	$ 12,837	$ 4,335	$ -	$ 2,500	$ -	0	1004	$ 20,675	$ 20,581	$ 41,257
Total cost Task 2 Year 1	**2915.5**	**$ 132,795**	**$ 44,845**	**$ 57,600**	**$ 9,000**	**$ 12,700**	**41000**	**9054**	**$ 306,994**	**$ 222,227**	**$ 529,221**
Task 3. Predator tracking: predator site fidelity	307	$ 6,876	$ 2,322	$ -	$ 10,090	$ 5,000	0	502	$ 24,790	$ 12,396	$ 37,185
Total cost Task 3 Year 1	**307**	**$ 6,876**	**$ 2,322**	**$ -**	**$ 10,090**	**$ 5,000**	**0**	**502**	**$ 24,790**	**$ 12,396**	**$ 37,185**
Task 4. Data Entry, QA/QC and Analysis	82	$ 6,472	$ 2,185	$ -	$ -	$ 1,500	0	113	$ 10,270	$ 10,361	$ 20,631
Total cost Task 4 Year 1	**81.8**	**$ 6,472**	**$ 2,185**	**$ -**	**$ -**	**$ 1,500**	**0**	**113**	**$ 10,270**	**$ 10,361**	**$ 20,631**
Task 5. Reports and presentations	80	$ 8,738	$ 2,951	$ -	$ 150	$ 2,160	0	282	$ 14,282	$ 14,031	$ 28,313
Total cost Task 5 Year 1	**79.8**	**$ 8,738**	**$ 2,951**	**$ -**	**$ 150**	**$ 2,160**	**0**	**282**	**$ 14,282**	**$ 14,031**	**$ 28,313**

Year 2

Year 2	Direct Labor Hours	Salary	Benefits	Travel	Supplies & Expendables	Services / Consultants	Equipment	Other Direct Costs	Total Direct Costs	Indirect Costs	Total Costs
Task 1. Project permitting		$ -	$ -						$ -	$ -	$ -
Total cost Task 1 Year 2	**0**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**0**	**0**	**$ -**	**$ -**	**$ -**
Task 2a. Project Location and Habitat Selection		$ -	$ -						$ -	$ -	$ -
Task 2b. Weekly predator sampling for food habits	1425	$ -	$ -						$ -	$ -	$ -
Task 2c. Opportunistic predator sampling for food habits	835	$ -	$ -						$ -	$ -	$ -
Task 2d. Analysis of stomach contents	307	$ -	$ -						$ -	$ -	$ -
Total cost Task 2 Year 2	**2566.5**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**0**	**0**	**$ -**	**$ -**	**$ -**
Task 3. Predator tracking: predator site fidelity	307	$ 7,151	$ 2,415	$ -	$ 10,090	$ 5,000	0	502	$ 25,158	$ 12,829	$ 37,987
Total cost Task 3 Year 2	**307**	**$ 7,151**	**$ 2,415**	**$ -**	**$ 10,090**	**$ 5,000**	**0**	**502**	**$ 25,158**	**$ 12,829**	**$ 37,987**
Task 4. Data Entry, QA/QC and Analysis	164	$ 6,730	$ 2,273	$ -	$ -	$ 1,500	0	113	$ 10,616	$ 10,769	$ 21,385
Total cost Task 4 Year 2	**163.6**	**$ 6,730**	**$ 2,273**	**$ -**	**$ -**	**$ 1,500**	**0**	**113**	**$ 10,616**	**$ 10,769**	**$ 21,385**
Task 5. Reports and presentations	200	$ 12,117	$ 4,092	$ -	$ 200	$ 2,880	0	376	$ 19,666	$ 19,443	$ 39,109
Total cost Task 5 Year 2	**199.5**	**$ 12,117**	**$ 4,092**	**$ -**	**$ 200**	**$ 2,880**	**0**	**376**	**$ 19,666**	**$ 19,443**	**$ 39,109**

Year 3	Direct Labor Hours	Salary	Benefits	Travel	Supplies & Expendables	Services / Consultants	Equipment	Other Direct Costs	Total Direct Costs	Indirect Costs	Total Costs
Task 1. Project permitting		$ -	$ -						$ -	$ -	$ -
Total cost Task 1 Year 3	**0**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**0**	**0**	**$ -**	**$ -**	**$ -**
Task 2a. Project Location and Habitat Selection		$ -	$ -						$ -	$ -	$ -
Task 2b. Weekly predator sampling for food habits		$ -	$ -						$ -	$ -	$ -
Task 2c. Opportunistic predator sampling for food habits		$ -	$ -						$ -	$ -	$ -
Task 2d. Analysis of stomach contents		$ -	$ -						$ -	$ -	$ -
Total cost Task 2 Year 3	**0**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**0**	**0**	**$ -**	**$ -**	**$ -**
Task 3. Predator tracking: predator site fidelity		$ -	$ -						$ -	$ -	$ -
Total cost Task 3 Year 3	**0**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**0**	**0**	**$ -**	**$ -**	**$ -**
Task 4. Data Entry, QA/QC and Analysis	164	$ -	$ -						$ -	$ -	$ -
Total cost Task 4 Year 3	**163.6**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**0**	**0**	**$ -**	**$ -**	**$ -**
Task 5. Reports and presentations	519	$ 9,451	$ 3,192	$ -	$ 150	$ 2,160	0	282	$ 15,236	$ 15,155	$ 30,391
Total cost Task 5 Year 3	**518.7**	**$ 9,451**	**$ 3,192**	**$ -**	**$ 150**	**$ 2,160**	**0**	**282**	**$ 15,236**	**$ 15,155**	**$ 30,391**
TOTAL REQUESTED FUNDS											$ 761,443
Total Year 1	3548	$ 160,683	$ 54,263	$ 57,600	$ 19,240	$ 21,360	$ 41,000	$ 10,237	$ 364,384	$ 268,188	$ 632,572
Total Year 2	3237	$ 25,999	$ 8,780	$ -	$ 10,290	$ 9,380	$ -	$ 991	$ 55,440	$ 43,041	$ 98,481
Total Year 3	682	$ 9,451	$ 3,192	$ -	$ 150	$ 2,160	$ -	$ 282	$ 15,236	$ 15,155	$ 30,391
Total all years	7467	$ 196,133	$ 66,235	$ 57,600	$ 29,680	$ 32,900	$ 41,000	$ 11,511	$ 435,059	$ 326,384	$ 761,443
Total Task 1	164	$ 5,802	$ 1,959	$ -	$ -	$ -	$ -	$ 286	$ 8,048	$ 9,173	$ 17,221
Total Task 2	5482	$ 132,795	$ 44,845	$ 57,600	$ 9,000	$ 12,700	$ 41,000	$ 9,054	$ 306,994	$ 222,227	$ 529,221
Total Task 3	614	$ 14,027	$ 4,737	$ -	$ 20,180	$ 10,000	$ -	$ 1,004	$ 49,947	$ 25,225	$ 75,172
Total Task 4	409	$ 13,202	$ 4,458	$ -	$ -	$ 3,000	$ -	$ 226	$ 20,887	$ 21,130	$ 42,016
Total Task 5	798	$ 30,307	$ 10,235	$ -	$ 500	$ 7,200	$ -	$ 941	$ 49,183	$ 48,630	$ 97,813
Total all tasks	7467	$ 196,133	$ 66,235	$ 57,600	$ 29,680	$ 32,900	$ 41,000	$ 11,511	$ 435,059	$ 326,384	$ 761,443
check	-	-	-	-	-	-	-	-	-	-	-