2009 Addendum to the Interagency Ecological Program's 2008 Work Plan to Evaluate the Decline of Pelagic Species in the Upper San Francisco Estuary

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Due to a limited amount of new funding, a forward movement in work plan and program planning time lines, redirection of staff to other equally important tasks and continuation of the large majority of activities, the 2009 IEP POD work plan will be presented here as an addendum to the 2008 work plan.

The work included in the 2009 Addendum to the Interagency Ecological Program's 2008 Work Plan to Evaluate the Decline of Pelagic Species in the Upper San Francisco Estuary has an emphasis on modeling and integration of results, and responds to management interests by including temperature modeling, wastewater impacts, contaminants, salvage efficiency, 3-dimensional particle tracking and individual based modeling for striped bass and longfin smelt. The ammonia work includes source, fate, and transport modeling, field studies, and a review and syntheses of data and studies on the effects of ammonia on aquatic species. The temperature work is closely coordinated with the CALFED-funded CASCaDE project, and will analyze the trends of water temperature stress zones and refugia in the Delta.

The majority of the new activities described below (Table 1) are expansions of previously existing studies, with the exception of two new elements; a) Spatial and Temporal Variability of Delta Water Temperatures: Long-term Trends and the Dynamics of Refugia, and b) Pelagic Organisms Declines in the California Delta, The Book. In addition, there are three studies from the 2009 class of CALFED Science Fellows, two from the 2006 CALFED Science PSP that are now integrated into the POD work plan and one from the Ecosystem Restoration Program, all of which we consider POD-related.

The cost estimate for the entire 2009 POD program is $11,707,000 (Table 2). It is important to note however, that one of the monitoring and eight of the 14 new or expanded activities are currently impacted due to the mandatory state furloughs and the December 2008 'Stop Work Order,' respectively. The impacts of this are far reaching and could include the loss of integration between closely coordinated projects, missed field seasons, stranded investments, delayed results, contract expirations resulting in needed extensions, and the inability to retain experienced investigators, provide data used in management decisions, and conduct subcontracted work. In addition to harming individual study elements and investigators, the delayed work will impair the crucial integrative nature of the IEP POD work. The tight conceptual, spatial and temporal

coupling of many individual study elements is a critical and deliberate design feature for achieving the final ecosystem-level analysis and synthesis that is the goal of the POD investigations. The IEP and CALFED are looking for alternative sources of bridge funding to accomplish some of the work, but at the moment the entire ramifications are uncertain.

Table 1. A list of 2009 IEP POD activities, contract status, and if the activity has been impacted by the December 2008 stop-work order. Details of activities identified in section 3 are provided in the text below.

		Contract Status (O = ongoing, I = in process, U = pathway undetermined, E = expired)	**Impacted or delays** (Stop Work Order = SWO or mandatory state furloughs = F)
1. Expanded monitoring			
PEN	**Title**		
2009-003	Fall midwater trawl	O	
2009-007	Summer townet survey	O	F - potentially
2009-033	20mm survey/smelt larvae survey	O	F
2009-072	Environmental monitoring program	O	
2009-089	Directed field collections	O	
2. On-going work			
PEN	**Title**		
2009-017	Larval fish behavior study		
2009-038	Development of striped bass and longfin smelt models	I	
2009-041	Modeling delta smelt populations in the S.F. Estuary	O	SWO
2009-043	Estimation of pelagic fish population sizes	O	
2009-044	Zooplankton fecundity and population structure	I	
2009-045	Phytoplankton primary production and biomass	O	
2009-046	Overlap/Synthetic analyses of fish and zooplankton	O	
2009-062	Fish diet and condition	O	
2009-065	Trends in benthic macrofauna abundance and biomass	O	SWO
2009-076	Corbula salinity tolerance	O	
2009-079	Field survey of Microcystis bloom biomass and toxicity	O	SWO
2009-081	CASCadE	O	
2009-082	Food web support for delta smelt and other estuarine fishes	O	SWO
2009-084	Analysis of historical population dynamics	O	
2009-087	Investigation of power plant impacts	O	
2009-102	SAV abundance and distribution	O	
2009-106	Estimates of fish and zooplankton biomass	O	
2009-107	Fish facility history	E	

2009-108	Delta smelt culture facility	O	
2009-119	Delta fish biomass estimation	O	
2009-121	Endocrine disruptor study	O	
2009-125	Clifton court residence time	O	
2009-126	Long-term sources and early warning signals in turbidity	O	
2009-127	Contaminants and biomarkers work	O	
2009-130	Feasibility of using towed imaging systems	O	
2009-131	Acoustics to calculate dimensions of trawl openings	O	
2009-132	Effects of the cache slough complex on north delta habitat	O	
2009-133	Impacts of largemouth bass on the Delta ecosystem	O	
2009-135	Delta smelt genetics	O	SWO
2009-136	Bioenergetics of zooplankton prey species	I	
2009-137	Population genetics and otolith geochemistry of longfin smelt	O	
2009-139	Effects of Microcystis aeruginosa on threadfin shad	O	
2009-142	Investigating lower trophic levels of Suisun Bay food web	O	SWO
2009-144	Pyrethroid pesticide monitoring	O	
2009-145	Delta fish tissue selenium analysis	O	
3. New IEP, new CALFED or expanded IEP work			
PEN	**Title**		
2009-038	Development and implementation of IBM of striped bass and longfin smelt	I	
2009-138	Effects of wastewater management on primary productivity	O	SWO
2009-140	Mark-recapture to estimate delta smelt pre-screen loss and salvage efficiency	O	SWO
2009-141	3-D modeling of the Delta	I	
2009-143	Screening to determine impacts of waste water on delta smelt	O	
2009-146	Synthesis to develop a comprehensive regional monitoring program for the Delta	O	
2009-147	BREACH III: Evaluating and predicting restoration thresholds	O	SWO
2009-148	Spatial and temporal variability of Delta water temperatures	I	
2009-149	Pelagic Organism Declines in the California Delta, The Book	O	
2009-150	Plankton dynamics in the Delta: trends and interactions	O	SWO
2009-151	Trophic impacts of Microcystis on crustacean zooplankton	O	SWO
2009-152	Environmental controls on the distribution of harmful algae and their toxins in the San Francisco Bay	O	SWO
2009-153	Comparison of nutrient sources and phytoplankton growth and species composition	O	SWO
2009-154	Spatial and temporal quantification of pesticide loadings	O	SWO
4. Completed or terminated elements			
PEN	**Title**		
2007-018	Contaminant loads and disease in striped bass		
2007-036	Preliminary investigations of disease as a factor in the POD		

2007-039	Threadfin shad data analysis and population dynamics		
2007-112	Biomarkers workshop		
2008-042	Striped bass health investigations		
2008-051	Apparent growth rates of pelagic fishes		
2008-060	Evaluation of delta smelt otoliths		
2008-061	Pelagic fish liver histopathology		
2008-066	Evaluation of changes in pelagic fish habitat		
2008-078	Retrospective analysis of long-term benthic data		
2008-097	Hydrologic changes and Suisun Bay increased salinity		
2008-122	Food match-mismatch study		
2008-124	Contaminants synthesis		
2008-129	Upstream migration cues for Osmerids		

Element descriptions: New IEP, new CALFED or expanded IEP work

Development and Implementation of Life-cycle Models of Striped Bass and Longfin Smelt in the Bay-Delta Watershed

IEP 2009-038 (Expansion of existing element)

Point person: Ted Sommer (DWR)

Lead Agency: UCD

Description: Recent declines in the abundances of several pelagic fish species have increased the need for data-supported quantification of the relationships between dynamics of the striped bass population and the ecosystem components that affect striped bass. The striped bass individual-based life-cycle model (IBM) contract ends in February 2009 and the model is at a point where different scenarios could be run through it. Potential scenarios include effects of temperature, food web shifts, diversions/operations, modified habitat preferences, contaminant accumulation, mortality rates, peripheral canal and changes in slot limits of the adult fishery. A two-year amendment beginning in March 2009 would include two tasks.

Task 1: The striped bass population life-cycle model will be extended into a generalized modeling framework applicable to other fish species in the Bay-Delta. Activities under this task will focus on generalizing the modular C++ format as well as creating several graphical user interfaces (GUIs) to facilitate the import of both life-stage processes and data into the IBM. The GUIs will extend the potential user pool of the IBM by providing accessibility to individuals with non-programming background. The computer code will be provided open-source for individuals wishing to modify the internal working structure of the IBM.

Task 2: The generalized modeling framework developed under Task 1 will be applied to longfin smelt in the Bay-Delta. Abundance measures and rate expressions for specific life-stage processes (e.g. growth, mortality, and fecundity) will be obtained from all permissible and existing data sources. Bioenergetics rate parameters will be obtained from Lantry and Stewart's (1993) work with rainbow smelt in the Great lakes. The resulting IBM will be useful in exploring the relative significance of specific factors

influencing population numbers of longfin smelt and in the prioritization of future data collection.

Time period: The expected duration of this project is 24 months. The schedule of deliverables (below) assumes that funding will begin on June 1, 2009.

Resources required

Cost: Year 1 = $232,000 and year 2 = $220,000 (USBR → DWR → UC Davis)

PI(s): Frank Loge (UCD)

Contract needed / in place: In process

Contract managers: Erwin Van Nieuwenhuyse (USBR) and Rich Breuer (DWR)

Term of contract: TBD

Personnel: Tim Ginn, David Ostrach, Kenneth Rose, Arash Massoudieh, and Kai Eder

Deliverables and dates:

- Progress report 1 (October 2009)
- Progress report 2, IEP newsletter article and presentation (April 2010)
- Progress report 3, CALFED Science presentation (October 2010)
- Progress report 4, IEP newsletter article and presentation (March 2011)
- Submission of 3 manuscripts, computer codes for each model, supporting documentation explaining use, inputs and outputs (June 2011)

Effects of Wastewater Management on Primary Productivity in the Delta

IEP 2009-138 (Expansion of existing element)

Point person: Anke Mueller-Solger

Lead Agency: SFSU, RTC & Water Boards

Questions: 1) Do wastewater treatment plants (WWTPs) effluents affect phytoplankton primary production and community composition in the Delta? 2) Do different wastewater treatment processes result in different phytoplankton responses?

Description: Primary production rates and standing chlorophyll levels in the Sacramento-San Joaquin Delta Estuary are among the lowest of all major estuaries in the world and may be declining further. The reason(s) for this are unclear but decreasing primary production rates are cited as a possible cause of the pelagic organism decline (IEP, 2007).

Recent work by Dugdale et al. (2007) and Wilkerson et al. (2006) has shown that elevated ammonia concentrations reduce phytoplankton production rates in San Francisco and Suisun Bays by inhibiting nitrate uptake. A recent review of ammonia concentrations in the Delta by Dr. Anke Mueller-Solger (CALFED Science Program) has shown that ammonia concentrations in the Sacramento River at Greene Landing are about an order of magnitude higher than concentrations reducing diatom growth rates by half in San Francisco Bay. Should phytoplankton production in the freshwater Delta be suppressed in the same way, this may contribute to the long-term declines in pelagic productivity and thus constitute an important "bottom-up" factor in the POD conceptual model. Furthermore, ammonia concentrations in the Sacramento River at Greene Landing have increased about 3% per year over the last 30 years. The primary sources of ammonia to the Delta are sewage treatment plants, principally the Sacramento Regional Wastewater Treatment Plant (SRWTP). Not known is whether ammonia, at concentrations measured

in the Delta, inhibit freshwater diatom production rates (similar to that observed in San Francisco and Suisun Bays) and are a contributing cause to the low primary production rates in the Delta.

This work plan element focuses on the SRWTP discharge to the lower Sacramento River in the legal boundary of the Delta. SRWTP employs secondary treatment and the main form of nitrogen in its effluent is ammonium. Field studies will include transect surveys of nutrients and phytoplankton as well as phytoplankton "grow-out" enclosures experiments (e.g. Dugdale et al. 2007) upstream and downstream of the SRWTP discharge location. Controlled laboratory experiments with added effluent, ammonium, and nitrate will complement the field study.

Time period: 2008 – 2010.

Resources required

Cost: $70,000 in 2009 through SWRCB
PI(s): Richard Dugdale, Alex Parker and Francis Wilkerson (SFSU)
Contract needed / in place: SWRCB contract in place
Contract manager: Mark Gowdy (SWRCB) and Chris Foe (CVRWB)
Term of contract: January 2008 through March 2010
Personnel: Above named investigators and two technicians
Equipment: None

Mark-Recapture Study to Estimate Delta Smelt Pre-screen Loss and Salvage Efficiency

IEP-related 2009-140 (2006 CALFED PSP)

Point person: Anke Mueller-Solger (CALFED)

Lead Agency: USFWS

Questions: What is the relation between salvage and total entrainment losses for juvenile and adult delta smelt at the State Water Project (SWP)?

Description: The purpose of this project is to evaluate the efficacy of mark-recapture tests to ensure a feasible approach to quantifying the extent of entrainment losses of juvenile and adult delta smelt (*Hypomesus transpacificus*) in the South Delta. Delta smelt was historically one of the most common open-water species of fish in the Sacramento-San Joaquin Delta. Delta smelt declined significantly between the late 1970s and early 1980s and is now listed as a threatened species by the Federal and State Endangered Species Act. Record low abundance indices for delta smelt and other pelagic fishes in the Delta have been observed since the early-mid 2000's Leading factors potentially implicated in this pelagic organism decline are water project operations, introduced species and contaminants. Despite the lack of information to quantify absolute entrainment losses of delta smelt to water exports and diversions, such losses have long been assumed to be a factor contributing to the decline of delta smelt and other species, particularly in the South Delta where the SWP and Federal Central Valley Project water export facilities are located.

- Task 1 - Project management
- Task 2 - Culture delta smelt for mark-recapture experiments
- Task 3 - Mark delta smelt for mark-recapture experiments
- Task 4 - Mark-recapture experiments for juvenile delta smelt

- Task 5 - Mark-recapture experiments for adult delta smelt
- Task 6 - Analyze and interpret results of mark-recapture experiments

Time period: August 2007 to July 2010.

Resources required

Cost: $292,000 (year 1), $363,000 (year 2) and $15,000 (year 3). This work is co-funded by CALFED Science and IEP (provides salaries of project lead and UCD staff).

PI(s): Gonzalo Castillo (USFWS), Robert Fujimura (DFG), Joan Lindberg (UCD), Jerry Morinaka (DFG), Victoria Poage (USFWS)

Contract needed / in place: In place, but delayed due to unforeseen logistical issues.

Contract managers: Kim Webb (USFWS), Rebecca Fris (CALFED)

Term of contract: August 2007 – July 2010

Personnel: Above named investigators and Jason Dubois (DFG), Luke Ellison (UCD) and scientific aids

Deliverables and dates:

- Progress report 1 and IEP Workshop presentation (March 2009)
- Progress report 2 (September 2009)
- Progress report 3 and IEP Workshop presentation (March 2010)
- Final Report (July 2010)
- Submission of one manuscript to a scientific journal (August 2010)
- CALFED Science presentation (October 2010)

Comments: This element was delayed due to unforeseen logistical issues. An additional sum of money (approximately $67,000), time and staff will be needed to mark hatchery-reared delta smelt with strontium isotope markers. The purpose of the strontium markers is to allow identification during salvage operations of any larval delta smelt produced as offspring of the released study fish. Funding mechanisms for this portion of the study are currently being explored. A result of this logistical delay is a reduction (50%) in the number of marked fish released.

3-D Modeling of the Delta

IEP 2009-141 (Expansion of existing element)

Point person: Fred Feyrer (USBR)

Lead Agency: DWR

Questions: What are the predicted pathways of particle movement through the Delta and what is the likelihood of entrainment in the pumps for different release locations and Delta conditions? How do wind-driven velocities influence the vertical migration behavior of fish in Clifton Court Forebay (CCF) and other regions?

Description: The focus of the present scope is to further refine the particle tracking simulation approach and simulate additional periods and scenarios. The scope is divided into five major tasks. Under the first task, the particle tracking approach will be refined to take into account additional biological variability (e.g., hatching rates and periods). Under the second task, the refined approach will be applied to periods of low abundance of delta smelt, such as 2007, 2008 or 2009. These particle tracking applications will focus largely on comparisons of model predictions with observed salvage to evaluate the

ability of the modeling approach to predict entrainment during recent years, which are characterized by low delta smelt abundance. Under the third task, the model will be applied to a hypothetical scenario of revised exports or operations. The results will be analyzed to access the effect of the changes on delta smelt entrainment. Under the fourth task, the model will be applied to simulate a period of field observations in CCF. The fifth task includes meetings, presentations, and documentation of the work completed under this scope of work.

Time period: June 2009 – June 2010. The expected duration of this project is 12 months assuming that funding will begin on June 1, 2009.

Resources required

Cost: $200,000 (USBR POD → URS)

PI(s): Edward Gross (URS)

Contract needed / in place: In process

Contract managers: Erwin Van Nieuwenhuyse (USBR)

Term of contract: June 2009 – June 2010

Personnel: Above named investigator

Deliverables and dates:

- IEP Presentation, February 2010
- Final Technical Report, May 2010

Screening to Determine Impacts of Wastewater on Delta Smelt

IEP 2009-143 (Expansion of existing element)

Point person: Stephanie Fong (CVRWQCB)

Lead Agency: SWRCB and UCD

Questions: Is delta smelt survival negatively impacted by ambient ammonia concentration in the Sacramento River with increasing concentrations causing increased mortality? Is delta smelt survival negatively impacted by one or more contaminants that are positively correlated with ammonia from the Sacramento Regional Wastewater Treatment Plant (SRWTP)? The results of this experiment will answer these questions and refute or confirm any potential association with the SRWTP.

Description: This work plan element will follow-up on results from the 2008 studies. Definitive laboratory dilution series will be repeated to confirm the previous results. In addition, parallel dilution series of increasing ammonia concentrations in Sacramento River samples will be repeated. Bioassay experiments will be conducted using 40 – 45 day old delta smelt. The first dilution series will consist of increasing ammonia concentrations (8.0, 4.0, 2.0, 1.0, 0.5, 0 mg-N/l) amended into Sacramento River water collected upstream of the SRWTP. The second dilution series will consist of four increasing concentration of SRWTP effluent amended into the same upstream river water as was used in the ammonia dilution series. Controls will consist of delta smelt hatchery water and hatchery water adjusted to low EC. Both tests will be performed at temperatures measured in the Sacramento River during times when larval delta smelt are present.

Time period: The experiment will be performed for 7 days in 2009.

Resources required

Cost: $25,000 in 2009

PI(s): Inge Werner, UCD
Contract needed / in place: In place
Contract manager: Mark Gowdy (SWRCB) and Chris Foe (CVRWQCB)
Term of contract: January 2008 to March 2010
Personnel: UCD, State and Regional Water Board staff
Equipment: None
Deliverables and dates: Final report and stakeholder meetings (summer 2009).

Synthesis to Support Development of a Comprehensive Regional Monitoring Program for the Delta and High Priority Monitoring and Studies to Investigate the Impacts of Contaminants and Discharges from Delta Islands on Beneficial Uses in the Delta

IEP 2009-146 (Expansion of existing element)
Point person: Stephanie Fong (CVRWQCB)
Lead Agency: CVRWQCB
Questions: What are the potential impacts of discharges from Delta islands on beneficial uses in the Delta? Are there data gaps with respect to ammonia concentrations and potential effects to species residing in the Delta, and, if so, what types of follow-up studies should be conducted? What are the effects of laboratory manipulations on the concentrations of pyrethroid pesticides in Delta waters and how do they influence the interpretation of toxicity test results?
Description: The Water Boards' strategic work plan for the Delta identified the need to develop a comprehensive regional monitoring program for the Bay-Delta as a high priority. Many agencies and groups monitor water quality, water flows, and ecological conditions in the Bay-Delta, but there is no comprehensive contaminants monitoring assessment program. The IEP, CALFED, and other organizations, including the Water Boards, conduct some of these analyses, but due to their specific mandates, information gaps exist. Emerging concerns with contaminants related to the POD, wastewater treatment plant discharges, agricultural discharges, pesticides, blue-green algae toxicity, and unknown toxicity events all highlight the need to improve contaminants monitoring. A system is needed for coordinating among monitoring programs and integrating contaminants monitoring into existing monitoring efforts whereby all data is synthesized and assessed on a regular basis.

While developing a comprehensive monitoring program for the Delta is a high priority, it will take time to coordinate considering the amount of monitoring required under Water Board programs as well as that being conducted by outside entities. In the interim, there is need to continue high priority monitoring activities, such as the monitoring being done by IEP to investigate the POD, as well as studies following up on monitoring results.

The purpose of this work plan element is to develop and synthesize information needed to support development of a comprehensive regional monitoring program for the Delta, conduct high priority monitoring and studies to investigate impacts of contaminants on beneficial uses in the Delta, and assess the impact of discharges from irrigated lands on beneficial uses in the Delta.
Time period: 2008 - 2010

Resources required

Cost: $450,000 for the entire contract; approximately $300,000 to be spent in CY2009.

PI(s): Michael Johnson (UCD)

Contract needed / in place: In place

Contract managers: Karen Larsen (CVRWQCB)

Term of contract: 2008 - 2010

Personnel: Above named investigator and additional technicians

Deliverables and dates:

Review and synthesis of existing ambient monitoring programs – A synthesis report will be prepared that summarizes the programmatic objectives, parameters and locations being monitored, the frequency of monitoring, and anticipated term of future monitoring for all ambient monitoring programs being conducted in the Delta and 30 miles upstream on the Sacramento and San Joaquin rivers. The report will include recommendations for a framework to coordinate these monitoring activities.

Review and synthesis of data and studies on the effects of ammonia on aquatic species – Existing data, studies, and literature on the effects of ammonia on aquatic species will be reviewed. A report will be prepared which synthesizes this information and identifies data gaps, if any, that exist with respect to ammonia concentrations and species residing in the Delta. A public workshop will be convened to present studies and gather information related to the impact of ammonia on Delta species and develop recommendations for future studies. Follow-up studies may be conducted based on recommendations from the public workshop.

BREACH III: Evaluating and Predicting 'Restoration Thresholds' in Evolving Freshwater-Tidal Marshes

IEP-related, 2009-147 (Ecosystem Restoration Program)

Point person: Pete Hrodey (USFWS)

Lead Agency: USFWS

Description: The purpose of this project is to provide a predictive level of understanding about (1) how abiotic and biotic factors in a restoring (levee breach) wetland, Liberty Island and Little Holland Tract, control vegetation colonization and expansion and subsequent responses by native fish and wildlife, and (2) how restoration processes influence local flooding and levee erosion over the course of the restoration. A quantitative approach to predicting the ecological responses to change in habitat structure will be developed as a restoring system passes through the vegetation recolonization threshold and continues to expand into a predominantly vegetated wetland landscape. The models used will also be valuable for interpreting or, with modification, even predicting alternative flood conveyance scenarios as the Island evolves. Specific tasks are as follows:

Informing Flood and Erosion Hazard Management Decisions

This task will address the knowledge gap concerning the risks of flooding and levee erosion associated with the projected geomorphic evolution of Liberty Island from flooded island to tule marsh and mudflat. The modeling results will inform resource management and planning processes related to the Lower Yolo Bypass.

Channel/Tidal Flat Morphology and Wave Climate
This task will measure channel and mudflat dimensions to provide time series data on landscape features and processes and investigate the geomorphic and ecological processes that define channel evolution across Liberty Island.

Landscape Structure and Change
This task will describe vegetation and geomorphology changes of Liberty Island from 1997 to 2008. Geomorphology, topography and data from other tasks in this agreement will be used to develop rules that govern the expansion and development of emergent vegetation after initial vegetation colonization. Qualitative and quantitative predictions of restoration landscapes and tidal channel development, both at Liberty Island and other Bay-Delta tidal freshwater restoration sites, will be produced.

Elevation Change
This task will quantify above-ground vegetative processes, below-ground biomass accumulation and sediment deposition responses to plant colonization on open mudflats as factors in elevation change of marsh substrate. Field studies will be structured to identify differences in soil building processes (i.e., rates, and the relative role of mineral sediment vs. organic accumulation) in newly colonizing vegetated areas.

Plant Colonization Dynamics
This task will study physiological tolerances and biotic interactions of key emergent wetland plant species under two sets of dispersal conditions in order to discover the opportunities and constraints for the establishment of key plant species. The experimental results will be used to produce an assessment of the range of suitable habitats for desirable species.

Macroinvertebrate Response
This task will identify macroinvertebrate assemblages associated with spatial and temporal development of the restoring tidal freshwater wetland. These assemblages will be monitored, in the vicinity of restoring wetlands, for changes during the course of vegetation colonization. Emphasis will be placed on monitoring the assemblages known to be the prominent prey of key fish species.

Nekton Response
This task will evaluate fish use of incipient vegetation colonization habitat structure and early expanding habitats by studying the use of restoring wetlands by specific life stages of delta smelt, longfin smelt, Chinook salmon, striped bass, threadfin shad and Sacramento splittail.

Food Web Sources and Pathways
This task will conduct monitoring for food web sources and pathways at Liberty Island to determine whether Liberty Island is a source or sink of organic carbon, phytoplankton and zooplankton biomass, nutrients and suspended solids. Local, exported and imported productivity, will be characterized at various scales.

Hydrodynamic and Morphological Modeling
This task will develop and apply a detailed numerical model to improve understanding of the physical processes (e.g. sediment supply, delivery, resuspension and redistribution) that control morphologic evolution of Liberty Island and to assess the validity of using models as predictive tools. Recommendations on how management and restoration activities can be applied to leveed sites within Liberty Island for a variety of desired endpoints will be prepared.

Development of Ecological Modeling Tools

This task will develop the Liberty Island Basin Model from process-based algorithms using existing models, modules, and other rules and inputs. Model parameters will be collected and developed sufficient to enable resource managers and restoration planners to assess restoration and management activity for long-term trajectories associated with levee breach restoration and other landscape alterations.

Development and Use of Predictive Modeling Tools Using a Synthesis Process

The models, modules, data, and other rules and inputs developed in previous tasks will be integrated to produce a system of linked hydrodynamic-ecological numerical models (model system). The model system will convert resource management and ecosystem restoration parameter inputs into ecosystem outcomes for a specified location and range of variables.

Time period: March 2008 – March 2011

Resources required

Cost: $2,440,000 over three years (CALFED ERP → DFG → USFWS → subcontractors) with approximately $900,000 allocated for year 1

PI(s): Pete Hrodey (USFWS), Charles Simenstad (UW), Philip Williams (PWA), Nadav Nur (PRBO), Denise Reed (UNO), Mark Hester (ULL), Enrique Reyes (ECU), Stephen Bollens (WSUV), and Peggy Lehman (DWR)

Contract needed / in place: Sub-contracts not in place and affected by the December 2008 'stop-work' order

Contract managers: Pete Hrodey (USFWS), Steven Rodriguez (DFG) and Leann Androvich (GCAP Services)

Term of contract: March 2008 – March 2011

Personnel: Above named investigators and additional technicians

Deliverables and dates:

Year 1:

- Quarterly progress reports
- Breach III internet website
- Flood and Erosion Hazard Analysis Report
- Restoration Practioners and Resource Managers Modeling Workshop

Year 2:

- Quarterly progress reports
- Restoration Practioners and Resource Managers Modeling Workshop

Year 3:

- Quarterly progress reports
- Restoration Practioners and Resource Managers Modeling Workshop
- Final task reports
- Final Hydrodynamic and Morphological Model Development
- Liberty Island Basin Model Development
- Final report
- Several peer-reviewed journal articles to follow

Spatial and Temporal Variability of Delta Water Temperatures: Long-term Trends and the Dynamics of Refugia

IEP 2009-148 (New)
Point person*:* Larry Brown (USGS)
Lead Agency: UC Berkeley
Questions: How do Delta water temperatures vary temporally and spatially? What are the historical trends in water temperature? Are there trends at the decadal and longer timescales that may be explanatory of the observed population declines? Spatially, how representative are point measurements of temperature in determining the thermal habitat of fish and other pelagic organisms? As an extension to this question, what is the spatial extent and persistence of thermal refugia? How do water temperature dynamics differ between Delta sloughs and the primary river channels? What is the spatial scale of interaction between these habitats?
Description: As global climate trends increase, Delta water temperatures are expected to increase, making delta smelt and other temperature-sensitive species more vulnerable. Previous work through the CASCaDE project has developed statistical models of water temperature that can effectively forecast over a 100-year time horizon for a number of different climate change scenarios. The statistical model employed uses air temperature, solar radiation and water temperature from the previous day. The resulting model is more than just a correlation of water temperature with atmospheric drivers, but also has an auto-regressive component. This approach successfully projects what water temperature would be measured at the instrumentation site but it is unclear how representative those temperature measurements are of local or regional water temperatures. Because all of the long-term stations are located along the channels of the Sacramento or San Joaquin rivers, the question of how representative the observed water temperatures are of conditions in other sloughs and channels in the Delta still needs to be investigated.
Task 1: Historical analysis of Delta water temperatures
The statistical model will be applied to the last century to examine how water temperatures have evolved in the last 50 – 100 years. The first step will be to collect and analyze historical atmospheric data (air temperature) which provides the dominate forcing of the statistical model. Once the forcing data is identified and processed, the model will be explored in back-casting mode, where calculations are run backwards in time. Analyses of backcast temperatures will be pursued as motivated by discussion with the POD managers during presentations of results and other meetings.
Task 2: Evaluating spatial variability of Delta water temperatures
This task will be accomplished by performing shorter timescale observations of spatial variability focused on the local variation of temperature in the vicinity of existing measurement stations and by performing regional studies of Delta water temperatures where thermistors in a number of channels will be deployed.
The short timescale observations will be performed on the Sacramento River near Rio Vista (due to its proximity to Cache Slough and the importance of this region to delta smelt) and the San Joaquin River near Prisoner's Point. Information from this task will look at the physical processes that determine spatial variability of water temperature and the mechanisms responsible for the spatial structure and temporal variability.
The regional studies will be focused in the Central and South Delta in order to complement the current study of Cache Slough dynamics. Information from this task will

help in understanding the interactions between water temperature changes in the primary river channels and adjoining smaller sloughs.

Task 3: Analysis and modeling

The primary modeling goal will be to develop descriptions of the spatial and temporal structure of water temperature locally and regionally surrounding historical measurements sites. Additionally, the investigators aim to develop a fundamental understanding of how temperature refugia may be developed and maintained.

Time period: June 2009 – June 2011

Resources required

Cost: Year 1 = $94,000 and year 2 = $89,000 (USBR → UC Berkeley, via CESU)

PI(s): Mark Stacey (UCB), Erwin Van Nieuwenhuyse (USBR)

Contract needed / in place: In process via CESU

Contract managers: Erwin Van Nieuwenhuyse (USBR)

Term of contract: June 2009 – June 2011

Personnel: Graduate student at UCB

Deliverables and dates: At the end of each year, a report will be submitted, including a summary of data collected and analysis pursued. In addition, 2 peer-reviewed publications and a PhD thesis will result from this research.

Pelagic Organism Declines in the California Delta - The Book

IEP 2009-149 (New)

Point person: Anke Mueller-Solger (CALFED)

Lead Agency: USGS and CALFED

Questions: What have we learned since the beginning of the IEP POD investigation in 2005 about individual and groups of stressors that currently affect pelagic fish population, the conditions under which these stressors occur, and the roles of these stressors in the most recent and in the longer-term declines of pelagic fishes in the upper San Francisco estuary? What are the remaining uncertainties?

Description: This work is intended to produce a book that would accompany and complement the comprehensive 2010 POD synthesis report and the specialized project reports and journal publications by individual POD principal investigators. This book will follow and update previous books bringing together results from studies in the San Francisco estuary (Conomos 1979, Hollibaugh 1996). It will be intended for a scientific audience but will also effectively communicate important conclusions to non-scientist readers.

In contrast to reports, the book will consist mostly of contributed chapters that are authored by individual, or in some cases, groups of POD principal investigators. This will allow for more in-depth presentation and discussion of results than can be summarized in reports. Results in the book will be presented in a more condensed, accessible, and consistent format than found in the individual project reports and diverse journal publications produced by POD investigators. In addition to the contributed chapters, the book will also include synthetic introductory and conclusion chapters and perhaps other synthesis text inserted into or interspersed with the contributed chapters. This additional text will be provided by POD MT members and NCEAS collaborators. It will give the

"big picture" perspective needed to understand each chapter in the POD context and also help guide the less scientifically minded readers of the book. POD MT members and a technical editor will edit the draft book chapters. All chapters will be peer-reviewed by a review panel and/or individual reviewers convened via CALFED and/or NCEAS.
Time period: June 2009 – June 2011.
Resources required
Cost: Year 1 = $0 and year 2 = $400,000 (USBR → USGS)
PI(s): Larry Brown (USGS) and Anke Muller-Solger (CALFED)
Contract needed / in place: An existing USBR/USGS contract will be modified to cover USGS staff time during year 2
Contract managers: Erwin Van Nieuwenhuyse (USBR)
Term of contract: Anticipated term of contract is June 2009 – June 2011
Personnel: POD Management Team members and other agency scientists and POD investigators not yet identified.
Deliverables and dates: Due to prior POD commitments and outstanding deliverables from a large majority of POD contracts, chapter writing would not take place until 2010. Therefore, year 1 would largely be devoted to organizing a framework and structure for the book, collecting information, creating an outline and identifying contributors. Year 2 would be devoted to chapter writing, editing and publication.

Plankton Dynamics in the Sacramento-San Joaquin Delta: Long-term Trends and Trophic Interactions
IEP-related 2009-150 (2009 CALFED Science Fellow)
Point person: Anke Mueller-Solger (CALFED)
Lead Agency: CALFED Science Program
Questions: What are the long-term trends of the Deltas zooplankton community and can distinct sub-regions be identified that show similar patterns? What are the long-term patterns in zooplankton species and functional groups? How does phytoplankton and environmental variability affect zooplankton production on a Delta-wide scale and appropriate sub-regions? Are seasonal patterns between primary producers and zooplankton consistent throughout the sampling record? How do changes in plankton community composition relate to biotic and environmental variation?
Description: This project seeks to identify: (1) long-term spatial and temporal patterns in zooplankton; (2) long-term interactions between primary producers and zooplankton; and (3) biotic interactions in the plankton community. Analyses of historical data, trends, seasonal variability, and foodwebs will be conducted using a variety of techniques appropriate to each analysis area.
Time period: 2 years (September 2008—September 2010)
Resources required
Cost: $164,797
PI(s): Monika Winder (UC Davis) and Geoffrey Schladow (UCD)
Contract needed / in place: In place
Contract managers: Rebecca Fris (CALFED)
Term of contract: September 2008—September 2010
Personnel: Above named investigators

Deliverables and dates:
Year 1:

- Annual progress report
- Presentations at local (Bay-Delta) and national or international professional meetings
- Draft of first manuscript

Year 2:

- Annual progress report and final research report summarizing results and accomplishments
- Presentations at local (Bay-Delta) and national or international professional meetings
- Peer-reviewed scientific publications (at least two are anticipated)

Comments: CALFED Science Fellows Project

Trophic Impacts of *Microcystis* on the Crustacean Zooplankton Community of the Delta

IEP-related 2009-151 (2009 CALFED Science Fellow)
Point person: Anke Mueller-Solger (CALFED)
Lead Agency: CALFED Science Program
Questions: How useful is qPCR as a monitoring tool for *Microcystis* ingestion? What are the trophic dynamics by which *Microcystis* changes the zooplankton community composition? Does *Microcystis* reduce the habitat quality of preferred fish prey such as *P. forbesi*? What zooplankton species benefit and suffer from increased *Microcystis*? Are there predictable changes in estuarine foodwebs due to *Microcystis* blooms? What is the contribution of *Microcystis* to the food limitation of pelagic fish?
Description: This project will investigate the contribution of *Microcystis* to the decline in pelagic organisms and test the hypotheses that *Microcystis* abundance causes predictable shifts in the San Francisco Estuary's zooplankton community. This will be done through a series of laboratory experiments and field measurements of in-situ ingestion rates. DNA-based markers will be applied using quantitative PCR to estimate ingestion rates under laboratory conditions with the target copepod, *P. forbesi*, and calibrated using established techniques such as radiolabeling. A combination of these techniques will be used to quantify in-situ ingestion rates of zooplankton in the field and in laboratory under controlled conditions.
Time period: January 2009-January 2011
Resources required
Cost: $164,931
PI(s): Kemal Ali Ger and Wim Kimmerer, (SFSU)
Contract needed / in place: In place
Contract managers: Rebecca Fris (CALFED)
Term of contract: January 2009-January 2011
Personnel: Above named investigators
Deliverables and dates:

- Develop PCR detection of *Microcystis* in *P. forbesi*, calibrate with radiolabels, quantify ingestion rates (March—July 2009)

- Determine in-situ ingestion in field and effects of community (July—October 2009)
- Develop PCR analysis of field ingestion (October 2009—January 2010)
- Data analysis, report, and manuscript preparation (January—March 2010)
- Determine ingestion under pre-bloom conditions (March—June 2010)
- PCR analysis to determine effects on pre-bloom community (June—August 2010)
- Data analysis, report, and manuscript preparation (August 2010—January 2011)

Comments: CALFED Science Fellows Project

Environmental Controls on the Distribution of Harmful Algae and Their Toxins in San Francisco Bay

IEP-related 2009-152 (2009 CALFED Science Fellow)
Point person: Anke Mueller-Solger (CALFED)
Lead Agency: CALFED Science Program
Questions: What predicted environmental changes favor dinoflagellates and cynobacterial growth in the South Bay and Delta, respectively? What predicted environmental changes will result in increased frequency in blooms of these species? Does alleviating light limitations due to stratification increase the influence of nutrient availability and relative concentrations, and does that result in enhanced toxicity of the harmful algae? Can spatial and temporal mapping of harmful algae and their toxins help explain the triggers for the algal blooms, and provide a baseline for measuring future trends and forecasting?
Description: This project will determine the distribution of harmful algae and their toxins in San Francisco Bay and characterize the environmental parameters that control toxin production by harmful algae in the Bay. It will combine monitoring and mapping of biological, chemical, and physical components throughout the Bay and Delta along with controlled manipulations to examine specific parameters likely to control growth and toxicity in the natural population of these species.
Time period: September 2008—August 2010
Resources required

Cost: $164,620
PI(s): Cecile Mioni (UCSC), Adina Paytan (UCSC)
Contract needed / in place: In place
Contract managers: Rebecca Fris (CALFED)
Term of contract: September 2008 – September 2010
Personnel: Above named investigators

Deliverables and dates:

- Monthly monitoring and data collection of harmful algae and toxins in the San Francisco Bay and Delta
- In-situ incubation experiments conducted seasonally
- Publications describing the results of the research
- Presentations describing the results of the research
- Monthly report cards describing the health of the Bay, published on the website
- Monthly reports of elevated levels of toxins or toxic algal in the Harmful Algal Blooms section of the website

Comments: CALFED Sciences Fellow Project

Comparison of Nutrient Sources and Phytoplankton Growth and Species Composition in the Sacramento and San Joaquin Rivers: Their Roles in Determining Productivity and Food Web Conditions in Suisun Bay and the Delta
IEP-related 2009-153 (2008 CALFED Science Supplemental Grant)
Point person: Anke Mueller-Solger (CALFED)
Lead Agency: SFSU-RTC & CALFED
Questions: 1) How do differences in nutrient and phytoplankton community composition between the San Joaquin (SJ) and Sacramento (Sac) Rivers influence conditions downstream in the Delta and Suisun Bay? 2) How do phytoplankton growth rates and community structure respond to the differences in nutrient concentrations in the SJ River vs. the Sac River, resulting from differences in wastewater treatment?

Description: Low primary production rates and changes in phytoplankton community composition may play an important role in the pelagic organism decline. Recent work by Dugdale et al. (2007) and Wilkerson et al. (2006) has shown that elevated ammonium concentrations reduce phytoplankton production rates in San Francisco and Suisun Bays by inhibiting nitrate uptake. The primary sources of ammonium to the Delta are wastewater treatment plants (WWTPs). It is not yet known whether ammonium, at concentrations measured in the Delta, inhibits freshwater diatom production rates (similar to the inhibition observed in San Francisco and Suisun Bays) and thus could be a contributing cause to the low primary production rates in the Delta.

This work plan element is closely linked to an ongoing CALFED project (PIs: Dugdale and Wilkerson; 4/2007 - 2/2010, Agreement #1039) focusing on phytoplankton production in Suisun Bay and extends these investigations into the Delta. It focuses on the effects of the two main WWTPs in the Delta: the Sacramento Regional WWTP (SRWTP) and the Stockton WWTP ("Stockton"). The SRWTP is the largest sewage treatment plant in the Delta. Its effluent is discharged into the Sacramento River at Freeport. It employs secondary treatment and the main form of nitrogen in its effluent is ammonium. The Stockton WWTP is the largest WWTP in the southern part of the Delta. It completed an upgrade to tertiary treatment in 2008 and now discharges primarily nitrate into the lower San Joaquin River in Stockton. These treatment differences, along with differences in river nutrient loadings, offer a great opportunity for a comparative investigation of the effects of regional differences in river and WWTP nutrient loadings on Delta phytoplankton. Field studies will include transect surveys of nutrients and phytoplankton along the Sacramento and San Joaquin rivers and as well as phytoplankton "grow-out" enclosures experiments (see e.g. Dugdale et al. 2007).

Field sampling will consist of under-way measurements of temperature, salinity, turbidity, fluorescence, as well as continuous sampling using flow cytometry and the FluoroProbe. Discrete sampling at river and Delta stations will include vertical profiles of temperature and salinity, and light penetration using a CTD fitted with a PAR sensor as well as by secchi disk. Water will be sampled at the surface and near the bottom for determination of inorganic nutrients (NO3, NO2, NH4, PO4, Si(OH)4), dissolved inorganic carbon (DIC), and size fractionated chlorophyll. Primary production and phytoplankton NO3 and NH4 uptake will be assessed under saturating light (50% of

PAR) and light limited (10% of PAR) conditions using 15N/13C tracer methods in light attenuated, flow-through incubators. Comparison of NH4 gradients along the river with 15NH4 uptake rates will provide an indication of nitrification. Samples will be collected for phytoplankton identification by microscopy, flow cytometry HPLC, and the FluoroProbe at each of the 24 discrete stations. Grow-out experiments will be conducted at locations downstream of the Sacramento and Stockton WWTPs. If NH4 depletion rates in grow-outs are greater than measured 15NH4 uptake rates this will suggest the presence of nitrification.

Time period: 2008 – 2010.

Resources required

Cost: $338,377 through a CALFED supplemental grant

PI(s): Richard Dugdale, Alex Parker and Frances Wilkerson (SFSU) and Anke Mueller-Solger (CALFED)

Contract needed / in place: In place

Contract manager: Steve Culberson (CALFED)

Term of contract: January 2008 through April 15, 2010

Personnel: Above named investigators and two technicians

Equipment: None

Deliverables and dates: Data and technical reports, presentations at IEP meetings, EET workshops and the CALFED Science Conference, publications in peer-reviewed journals. No specific deadlines are specified in the contract, but the end date is April 2010.

Spatial and Temporal Quantification of Pesticide Loadings to the Sacramento River, San Joaquin River, and Bay-Delta to Guide Risk Assessment for Sensitive Species

IEP-related 2009-154 (CALFED funded)

Point person: Rich Breuer (DWR)

Lead Agency: DWR

Questions: 1) What is the fate and transport of agricultural chemicals in the Sacramento and San Joaquin rivers? 2) When and where should we be looking for potential toxicity based on modeling results?

Description: A weight-of-evidence analysis is being conducted to identify major sources of pesticide loadings to the Sacramento River, San Joaquin River, and Bay-Delta estuary. The objective of this study is to improve decision making and optimize resource spending across a number of federal, state, and regional water quality programs. Objectives are being addressed through a combination of tools, including geographical information system (GIS) analysis, simulation modeling, and an evaluation of existing in-stream monitoring. Results are being used to: 1) provide further knowledge of the fate and transport of agricultural chemicals (e.g., copper, organophosphates) and emerging pesticides (e.g., pyrethroids), 2) match results to the location of sensitive species critical habitats, 3) identify and rank pesticide source areas, 4) evaluate implications of future pesticide use trends and changes in climatic conditions, 5) aid in developing plans to improve ecosystem quality and water quality by strategic placement of best management practices and hydrologic operations, 6) support future monitoring programs (strategic locations, sampling frequency), 7) link results to life cycle models currently under

development for striped bass and delta smelt, as well as existing models for salmonids, and 8) provide a data-link to support other water quality models and population models.
Time period: 2008 – 2010.
Resources required
Cost: $507,940
PI(s): Minghua Zhang, Ph.D., (UCD) and W. Martin Williams (Waterborne Environmental, Inc.)
Contract needed / in place: CALFED receivable and subcontracts to UCD and Waterborne Inc. in place
Contract manager: Brianne Noble (DWR)
Term of contract: July 2008 through June 2010
Personnel: Above named investigators and Technical Advisory Group (TAG) that provides technical direction on the project to ensure that cross-agency goals are met. The TAG consists of 15 members representing Federal and State agencies, Universities and private industry. Their involvement will begin at the initiation of the project to coordinate data collection and avoid duplication of efforts with other activities that either have occurred or are in progress. Interaction with the TAG will be continuous and iterative.
Equipment: None
Deliverables and dates: The TAG will receive progress reports and other interim communication and redirect efforts as necessary to maximize the success of this study.

Budget

The cost estimate for 2009 funds from DWR POD, USBR POD and SWRCB POD is approximately $7,474,000. CALFED grants that directly support various POD efforts or that will supply information useful to the POD effort are estimated at $4,099,000. Additional elements receive funding from the USFWS, totaling $134,000. Cost estimates for individual program components are provided in Table 2 and in the previous section as part of the project summaries. In some instances, money for 2009 work was obtained in 2008, therefore not reflected in the table below.

Table 2. Approximate 2009 POD budget by element and funding source (amounts are in $1,000).

ELEMENT NAME		FUNDING SOURCE					
	PEN[a]	POD Total	DWR POD	USBR POD	CALFED Science	SWRCB POD	Other
1. Expanded Monitoring							
Fall midwater trawl	3	$31		$31			
Summer townet survey	7	$36		$36			
20mm survey/smelt larvae survey	33	$255		$255			
Environmental monitoring program	72						
Directed field collections	89	$145		$145			
TOTAL for EXPANDED MONITORING		**$467**	**$0**	**$467**	**$0**	**$0**	**$0**

	PEN	POD Total	DWR POD	USBR POD	CALFED Science	SWRCB POD	Other
2. Ongoing Work							
Larval fish behavior study	17						
Modeling delta smelt in the S.F. Estuary	41	$332			$332		
Estimation of pelagic fish population sizes	43	$171	$85	$86			
Zooplankton fecundity and population structure	44	$75	$75				
Phytoplankton primary production and biomass	45	$25	$25				
Overlap/Synthetic analyses of fish and zooplankton	46	$1,357	$363	$994			
Fish diet and condition	62	$170		$170			
Trends in benthic macrofauna abundance and biomass	65						
Corbula salinity tolerance	76	$24	$24				
Field survey of *Microcystis* bloom biomass and toxicity	79	$250			$250		
CASCADE	81	$554			$554		
Food web support for delta smelt and other estuarine fishes	82						
Analysis of historical population dynamics	84						
Investigation of power plant impacts	87	$25	$25				
SAV abundance and distribution	102	$103	$103				
Estimates of fish and zooplankton biomass	106						
Fish facility history	107						
Delta smelt culture facility	108	$383	$96	$287			
Delta fish biomass estimation	119						
Endocrine disruptor study	121						
Contaminants synthesis	124	$150				$150	
Clifton court residence time	125						
Long-term sources and early warning signals in turbidity	126						
Contaminants and biomarkers work	127	$1,273		$1,273			
Feasibility of using towed imaging systems	130	$178	$41	$137			
Use of acoustics to measure trawl openings	131	$30		$30			
Effects of the Cache Slough complex on north Delta habitat	132	$468		$468			
Impacts of largemouth bass on the Delta	133	$373		$373			
Delta smelt genetics	135	$215		$81			$134[b]
Bioenergetics of zooplankton species	136	$68	$68				
Population genetics and otolith geochemistry of longfin smelt	137	$245		$245			
Effects of waste water management on primary productivity	138	$167	$77			$90	
Effects of *Microcystis* on threadfin shad	139	$370		$370			
Investigating lower trophic levels of Suisun Bay food web	142	$76			$76		
Pyrethroid pesticide monitoring	144	$300				$300	
Delta fish tissue selenium analysis	145						
TOTAL for ONGOING WORK		**$7,382**	**$982**	**$4,514**	**$1,212**	**$540**	**$134**
	PEN	POD Total	DWR POD	USBR POD	CALFED Science	SWRCB POD	Other

3. New IEP, new CALFED or expanded IEP work							
Development and implementation of IBM of striped bass and longfin smelt	038	$232		$232			
Effects of waste water management on primary productivity	138	$70				$70	
Mark-recapture to estimate delta smelt pre-screen loss and salvage efficiency	140	$292			$292[c]		
3-D modeling of the Delta	141	$200		$200			
Screening to determine impacts of waste water on delta smelt	143	$25				$25	
Synthesis to develop a comprehensive regional monitoring program for the Delta	146	$350		$50		$300	
BREACH III: Evaluating and predicting restoration thresholds	147	$1,500			$1,500		
Spatial and temporal variability of Delta water temperatures	148	$94		$94			
Pelagic Organism Declines in the California Delta, The Book	149						
Plankton dynamics in the Delta: trends and interactions	150	$83			$83		
Trophic impacts of Microcystis on crustacean zooplankton	151	$83			$83		
Environmental controls on the distribution of harmful algae and their toxins in the San Francisco Bay	152	$83			$83		
Comparison of nutrient sources and phytoplankton growth and species composition	153	$338			$338		
Spatial and temporal quantification of pesticide loadings	154	$508			$508		
TOTAL for NEW WORK		**$3,858**		**$576**	**$2,887**	**$395**	**$0**

	Overall POD	**DWR POD**	**USBR POD**	**CALFED Science**	**SWRCB POD**	**Other**
2009 POD TOTAL	**$11,707**	**$982**	**$5,557**	**$4,099**	**$935**	**$134**

[a]/ Program Element Number

[b]/ Funding source is United States Fish and Wildlife Service

[c]/ Additional need (~$67,000) for marking hatchery-reared fish with strontium isotopes is being explored.