Summary Information

University of California, Davis

Monitoring responses of the Delta Smelt population to multiple restoration actions in the San Francisco estuary

Amount sought: $2,658,648

Duration: 36 months

Lead investigator: Dr. William Bennett, University of California, Davis

Short Description

This project requests three years of support to implement a state−of−the−art monitoring program to link key vital parameters for individual delta smelt with survival to adulthood at the population level. Our plan is to measure five vital parameters for fish collected by the IEP, including growth and body condition, exposure to toxic chemicals, survival to the adult stage, spawning success, and feeding and food selectivity. We previously developed the methodology for measuring four of these parameters for delta smelt and the fifth is a standard technique. Our approach is novel because it combines information from histopathology of fish tissues, gut contents, and analyses of fish growth from otoliths to distinguish among mechanisms influencing the state of the individual fish. By combining this information on surviving fish with region−specific information on the vital rates and risk of loss to the water export facilities, we can begin to discern what combinations of environmental conditions result in high or low survival and population abundance.

Executive Summary

Restoring the threatened delta smelt (Hypomesus transpacificus) population has remained a primary goal of CALFED for a decade. Numerous restoration actions have been proposed or implemented to provide benefits for delta smelt, yet a coherent plan for investigating the population or its responses to concurrent restoration actions does not exist. Monitoring for delta smelt occurs at a few restoration sites, and throughout the species' range by the Interagency Ecological Program (IEP). However, there is no systematic effort to link across scales of biological organization to understand population−level responses. Environmental change including restoration affects individuals through growth rates, fecundity, or mortality risk; population responses then arise from the cumulative outcome of these individual responses. Therefore, to understand the efficacy of restoration we must quantify these vital

parameters for individual fish, and interpret results in the context of the entire delta smelt population.

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Our approach is novel because it combines information from histopathology of fish tissues, gut contents, and analyses of fish growth from otoliths to distinguish among mechanisms influencing the state of the individual fish. In addition, we now have the technology to use the composition of chemical elements incorporated in otoliths to provide a chemical history of a fish’s movements. This enables us to identify in which of four major regions each fish hatched, and where it has spent its time during rearing. By combining this information on surviving fish with region−specific information on the vital rates and risk of loss to the water export facilities, we can begin to discern what combinations of environmental conditions result in high or low survival and population abundance. The overall synthesis will provide the most novel and technologically advanced monitoring for understanding the spatiotemporal patterns by which various factors interact to influence population abundance. In other words, we will proceed from what we can reliably measure to what matters for the population (and the species) and therefore what is important to management. Our plan is also extremely cost−effective and environmentally friendly: we will extract the greatest possible amount of information from fish that will be collected and therefore killed in the course of monitoring.

Our proposed work plan is central to several CALFED ERP Strategic Goals and priorities. Delta smelt is the most at−risk native species in the Delta and Suisun Bay; it is also at the heart of environmental controversy over the allocation of fresh water in California. We anticipate regular reporting on the status of this work to CALFED, as well as through scientific publications. With our program in place we would be able to evaluate the performance of delta smelt at a variety of scales, and produce results that will be integrally linked with the IEP and other monitoring programs to guide CALFED restoration and management efforts.

MONITORING RESPONSES OF THE DELTA SMELT POPULATION TO MULTIPLE RESTORATION ACTIONS IN THE SAN FRANCISCO ESTUARY

A. Project Description: Project Goals and Scope of Work.

1. Problem, Goals and Objectives:

A primary goal of the CALFED Ecosystem Restoration Program (ERP) is to recover at-risk native species, particularly the delta smelt (*Hypomesus transpacificus)*, currently listed as threatened under the Federal and State Endangered Species Acts (CALFED 2000). A variety of ecosystem restoration actions have been implemented to "improve and increase aquatic habitat and ecological functions" (CALFED 2000) in the hope of restoring the delta smelt population. However, a coherent plan to investigate the relative importance of various mechanisms influencing the population or the effectiveness of the restoration initiatives does not exist.

Local monitoring for fish occurs at a few of the restoration sites, but there is no way to track the extent to which delta smelt use restored sites and whether restoration benefits those individuals or the population. Similarly, extensive monitoring of most life stages of delta smelt by the Interagency Ecological Program (IEP), which produces the official measures of delta smelt abundance, can detect trends in the population in space and time, but cannot reveal causes of spatial or temporal variability in delta smelt (Bennett 2004). Both types of monitoring are vital components for assessing the potential benefits of restoration actions; however, both must be explicitly linked with quantitative measures of the mechanisms by which changes in habitat influence the population.

Missing from the current mix of monitoring programs is any systematic effort to link across scales of biological organization. Fish respond to their environment as individuals; what we see as a population response is actually the cumulative outcome of many individual responses. Restoration or other management actions affect local conditions, which in turn affect individual fish through changes in growth rate, fecundity, or mortality risk. Therefore to understand the population-level consequences of restoration, it is necessary to look beyond mere numbers of fish, and to measure variables that provide information about these vital rates.

Our primary goal is to implement a state-of-the-art monitoring program to link key vital parameters for delta smelt collected by existing monitoring programs with survival to adulthood. The unit of interest in this monitoring program is the individual fish. Advances in understanding and measurement techniques allow us now to investigate how individuals vary in their current and historic state, as determined by vital parameters such as growth rate and feeding success. These vital parameters can then be traced to likely times and regions of influence, either positive or negative, on the smelt. When these parameters have been measured on individuals collected throughout the year and over the entire range of the species, influences contributing to year-class success can be determined and traced to their source. This will provide the most novel and technologically advanced monitoring, allowing us to assess the value of habitat restoration by providing mechanistic linkages between local habitat improvements and the abundance patterns as determined by ongoing IEP surveys. Delta smelt are a threatened fish, therefore, our plan is extremely cost-effective and environmentally friendly because we are proposing to extract the greatest possible amount of information from fish that will be killed and eventually discarded in the course of monitoring population abundance.

Out of the 165 actions listed by the ERP (http://calwater.ca.gov/Solicitation/ERP_PSP_Tools.), at least 15 propose benefits to delta smelt. Of these, actions at 9 sites (Figure 1) claim to be improving habitat for delta smelt by:

- creating shallow-water habitat, or restoration of natural flow regimes by levee breaches or flooding of islands
- improvements in water quality through reclamation of salt ponds or reductions in toxic chemicals in runoff.

Although these restoration actions are well intended and involve significant investment and effort, rarely are the proposed benefits to the smelt population specifically defined. Most of actions are small in scope relative to the entire delta smelt habitat, and are occurring simultaneously without any pre-project data, thereby preventing a linkage of these actions to the smelt population. Thus potential benefits will be difficult to decipher from the variety of overlapping influences on the population.

To understand how restoration actions influence delta smelt, we must first define the mechanisms through which population-level benefits might arise. Improvements in habitat quantity or quality resulting from restoration are likely to influence five factors that can be measured for delta smelt and used to assess population-level benefits. *Our objectives are to make concurrent, linked measurements of the following population variables to help understand how environment, restoration, and management activities affect the fish:*

1. Growth efficiency and body condition
2. Impairments from exposure to toxic chemicals
3. Survival to the adult stage.
4. Spawning success
5. Food composition and abundance

We previously developed the methodology for measuring the first four of these parameters for delta smelt (reviewed in Bennett 2004); the fifth is a standard technique. Our approach is novel in combining various sources of information about the state of individual fish. For example, we will combine information from fish otoliths with that from histopathology of tissues to distinguish among potential mechanisms influencing fish condition and growth (reviewed in Bennett 2004). This information, together with direct information on feeding, will give us a complete picture of the nutritional status and health of each fish. In addition, we have recently developed the technology to identify micro-chemical signatures in delta smelt otoliths, which provide a chemical history of the fishes historical movements. With this technique we can now trace the natal origins, as well as track the occurrences of these fish throughout their life history to four regions within the estuary that encompass the delta smelt habitat (Hobbs et al. 2004a). Thus, we can reliably measure changes in vital rates and then link them to a specific region in which they occurred.

Restoration actions at the 9 sites targeting delta smelt fall neatly within the regions identified using the chemical signatures in otoliths (Figure 1). They include:

- North Delta - Sacramento River region
- Central Delta - San Joaquin River region
- Suisun Marsh region
- Napa River region

Our primary objective, therefore, is to collaborate with the system-wide monitoring by the IEP and with local monitoring efforts at the restoration sites to collect and archive delta smelt for analysis using the above approach. Our second objective is to apply the same methods to fish collected during water export operations at the South Delta facilities. This is important because potential benefits from restoration may help to compensate for, or could be offset by, the large numbers of young delta smelt lost during water export operations (Bennett 2004). Finally, we propose to spend a modest amount of effort to develop methodology to census delta smelt egg production and spawning to further address parameter 4 above.

We propose this monitoring program as Phase 1 of a multi-phase project, with the intention of further refining our methodology, increasing the numbers of samples, and encouraging involvement by all relevant restoration projects as they come on-line in subsequent phases.

Our proposed monitoring also satisfies various criteria deemed as priority needs by the CALFED ERP as outlined in the PSP. Our program can track trends, evaluate implementation, assess effectiveness, and provide measures for model validation of restoration actions. It provides a multi-institutional initiative, involving scientists at the University of California, San Francisco State University, and the IEP, as well as potential contributions from environmental groups and municipalities involved with local restoration. The partnerships established with this program also provide a highly interdisciplinary approach that may serve as a backbone onto which additional projects funded from diverse sources may be linked. Moreover, with this program we would have the ability to evaluate the performance of delta smelt at a variety of scales, and produce results that would be integrally linked with the IEP and other monitoring programs, and facilitate the work of the interagency Data Assessment Team (DAT) in refining the Delta Smelt Risk Assessment Matrix (DSRAM).

Background on the life cycle

The following discussion is based mainly on the recently submitted review paper on the ecology of the delta smelt population (Bennett 2004). Key features are outlined in our conceptual model (Figure 1) that depicts the spatiotemporal extent of the population, our monitoring emphasis, and

general approach for measuring delta smelt vital parameters. Nine restoration actions (solid circles) and the natal regions (open ovals) within the delta smelt habitat (yellow shading) are linked to a life-cycle diagram showing the temporal sequence of various processes that influence survival at the different life-stages sampled by the IEP monitoring surveys (Figure 1).
Delta smelt are primarily an annual species with a small number of individuals living and potentially spawning at two years of age. Our monitoring will concentrate on four key periods of the life cycle, each of which is surveyed by the IEP. All IEP monitoring programs discussed here sample throughout the range of the concurrent life stage of delta smelt, and all take ancillary measurements including temperature, salinity, and length of the fish.

Spawning season: Adult delta smelt spawn in freshwater in spring when water temperatures lie within about 15 to 20ºC. Adult fish are monitored by the spring Kodiak trawl survey from March to May, and fish are identified to reproductive state. Spawning distribution, inferred from monitoring of fish during the transition from ripe to spawned condition, varies with hydrological conditions. In dry years delta smelt spawn primarily in the North Delta region, while in wet years spawning is more evenly distributed among regions, including the Napa River. Pesticides that enter the habitat with freshwater run-off from agricultural fields in late winter may impair egg or sperm development in some regions (Thompson 2000, Bennett 2004). Restoration actions may improve spawning success in different regions by creating shallow-water habitat or by improving water quality. However, if restored habitats are dominated by exotic fishes such as inland silversides, improvements in spawning could be offset by increased predation on delta smelt larvae (Bennett and Moyle 1996, Bennett 2004).

Delta smelt spawn adhesive eggs, but little is known of the spawning habitat other than they probably utilize shallow-water or shoreline areas, as does their closest relative the surf smelt (*Hypomesus pretiosus*), a marine species that sometimes frequents the estuary. Only one egg has been found in the field (K. Fleming, DFG, pers. Comm.). Since the eggs are stationary, a potentially useful tool for assessment and management would be to develop a survey method for eggs, similar to that used to assess the abundance of adult herring in the San Francisco Bay herring fishery. A pilot egg survey is part of our proposed study design.

Post-larval stage: Delta smelt hatch out as yolk-sac larvae and grow and develop on endogenous energy supplies until they begin to feed at about 5 mm total length (TL). At about 15-20mm TL delta smelt are considered post-larvae: they have finished developing a functional swim bladder and fin-folds. This life-stage is monitored by the 20mm survey from April to June. The initial distribution of post-larvae is generally similar to that of adults during the spawning season, but the smelt move seaward so that they are in the Low-Salinity Zone (LSZ) by July (Bennett et al. 2002). As in many fishes, survival through this stage is influenced by several factors (Figure 1). Feeding success and exposure to toxic pesticides may be especially important, either directly causing mortality or, more likely, by impairing growth and reducing survival. Rapid growth during early life history is an essential feature of recruitment success in fishes because losses to predation tend to be highest on the smallest fish (Houde 1987, 1989).

Feeding success at first feeding and later may be particularly poor for delta smelt because the composition of their zooplankton prey has been changed dramatically by the introduction of several exotic species over the last 2-3 decades (Kimmerer et al. 1994, Kimmerer and Orsi 1996, Orsi and Ohtsuka 1999, Nobriga 2002). Biomass of calanoid copepods, which are the principal prey of delta smelt (Nobriga 1998, 2002, Lott 1998), has been lower in spring in and near the LSZ, including the western Delta, since 1987. Total copepod biomass has been supplemented since 1993 by the introduced cyclopoid copepod *Limnoithona tetraspina*, but this copepod is apparently too small to be readily consumed by delta smelt (Lott 1998, Bouley 2004).

Pesticides are known to occur in the regions occupied by larval and post-larval delta smelt (Kuivila and Foe 1995, Crepeau and Kuivila. 2000, Moon et al. 2000, Thompson et al. 2000, Bennett 1996, 2004). We previously detected growth impairments in delta smelt post-larvae due to poor feeding and toxic exposure (summarized in Bennett 2004). Entrainment in the freshwater export facilities also causes considerable mortality during this period. Currently, however, this mortality is estimated only for fish larger than 20mm, and the extent to which entrained fish reflect only those spawned in the south Delta (lower portion of our Central Delta region), or arrive there from other areas of the Delta, is a topic of considerable uncertainty. Restoration actions that improve flow regimes and water quality, or create habitat, may enhance preferred prey species and feeding success, and reduce impairment from exposure to toxic chemicals. However, such benefits may be offset by increases in fish entrainment. Restoration actions that create or improve habitat may enhance juvenile survival if the changes do not favor exotic fishes disproportionately (Grimaldo et al. 2004, Bennett 2004).

<u>Juvenile stage:</u> The juvenile stage is monitored primarily by the summer tow-net survey from June to August, and the September fall mid-water trawl survey. Our previous work showed that a recruitment bottleneck may occur in late summer as juveniles transition into the adult stage. A stock-recruit model (Figure 2) indicated that survival during this transition may be density dependent in some years. Approximately 60% of juveniles examined in our previous study had growth impairments due to poor feeding success at this life-stage (Bennett 2004). Food abundance, competition, and habitat volume are commonly associated with density-dependent survival (Houde 1987, 1989, Cowan et al. 2000, Rose et al. 2001) and a similar relationship exists for juvenile striped bass (Kimmerer et al. 2000), but the factors contributing to this pattern of density dependence or to poor-feeding success in late summer are currently unknown (Bennett 2004).

<u>Adult stage:</u> Delta smelt adults are monitored by the fall mid-water trawl survey from October to December. During this period we will primarily focus our efforts on understanding the natal origins and occurrences of adults to define the relative contribution made by the various sub-regions to annual year-class success.

2. Justification:

As a "big-R" species, delta smelt have been a priority of CALFED for about a decade. The need to implement a cohesive scientific program to guide recovery efforts has been identified in the CALFED Ecosystem Restoration Program Strategic Plan, Stage 1 Implementation Plan, the Comprehensive Monitoring and Research Program (CMARP), and by a variety of CALFED scientific review panels (EWA Review Panel summary 2003), workshop proceedings (Brown and Kimmerer 2001, Kimmerer and Brown 2003), as well as the IEP Delta Smelt Research Strategy. Clearly, this need is even more compelling if we are to understand influences from a variety of significant restoration actions proposing to provide benefits for delta smelt.

Restoration actions must be evaluated at the population level. Although each restoration action involves considerable effort and capital investment, each is small in scope relative to the distribution of the delta smelt population. Thus, there is no assurance that a higher occurrence of delta smelt at restored sites has any influence on abundance or overall spawning success of the population. Moreover, there is no way to determine if potential benefits to delta smelt compensate for, or merely contribute to, fish lost to the water export facilities. Therefore, a program to assess benefits from restoring habitat needs to link local monitoring efforts at the restoration sites to population-level monitoring by the IEP, as well as fish taken by the water export facilities.

The goal of our work is to provide that linkage by implementing a monitoring program that measures several vital parameters for delta smelt reflecting individual responses to habitat quality. Because we also now have the ability to trace where these responses occurred during a fish's life, we can measure how changes in habitat quality may benefit delta smelt in different sub-regions. Our approach provides powerful integration across scales of biological organization, as well as in time and space, by extracting various types of information from large samples of individuals. Furthermore, we reiterate that this sampling will occur at little further cost in mortality to the delta smelt population, since most of our smelt will come from existing monitoring programs.

The primary strength of our interdisciplinary approach is its ability to integrate across a variety of scales to assess the spatiotemporal patterns by which various factors influence the delta smelt population. The conceptual pathways through which restoration actions may benefit the delta smelt population are shown in Figure 3. Restoration actions may benefit delta smelt at regional and population levels through changes in the spawning and feeding environment, water quality, and the fraction of fish entrained by the water export facilities. These actions have effects on the immediate environment of delta smelt, which in turn evoke responses of individuals that combine to determine a population response. The individual responses can then be measured, providing a way to trace effects back to their origins.

An alternative view of the measurements being taken (Figure 4) illustrates how different classes of measurements provide information on different vital rates. Individual variability due partly to spatial and temporal variability in the environment, together with risk of entrainment in export facilities, results in high or low survival for different subgroups of the population. The studies of otolith micro-chemistry on adult fish will provide information on the origins of the survivors, and will enable us to interpret the individual-based information measured on the younger fish. This powerful approach will enable us to determine what factors are most important in determining survival, and how those factors may interact.

By combining knowledge of the key predictors of high survival (e.g., good feeding success) with measurements of these predictors on fish collected near restoration sites, we will be able to at least begin to assess the efficacy of various classes of restoration actions in benefiting delta smelt.

3. Previously Funded Monitoring:

Our previous work focused on developing the techniques and overall approach, cooperating with the IEP sampling programs to collect specimens. Relatively speaking it was limited in scope as a monitoring program. We are now proposing to implement the approach as a program specifically linking various restoration actions to establish a mechanism for assessing their relative benefits to the population.

4. Approach and Scope of Work:

We propose a 3-year monitoring program to link individual variability in fish condition to population-level responses by focusing on vital parameters most likely to influence year-class strength. We approach this problem from two directions: we will examine key determinants of survival at the individual level, specifically those that influence individual growth rate, focusing on larvae and juveniles originating in each of the four regions. We will then determine the age, growth rate, and geographic origin of surviving fish to determine where most of the survivors come from, looking back in time to determine which sets of conditions and responses most closely predict success. Effects of export pumping occur at the sub-population level (i.e., we assume the probability that a fish will be killed at the pumps depends only its position, not its condition), and these will also be factored into the retrospective analysis. This will enable us to determine the relative importance of export losses in each of the four regions, in comparison to other sources of mortality.

We propose to use delta smelt collected by the IEP monitoring surveys, as well as from restoration projects as they initiate local monitoring for fish. For these fish we will then examine a suite of biological responses using histopathology of fish tissues, as well as growth and assessment of natal origin using otoliths. These measurements we will then be used as input to size-structured and individually-based population models, pending funding of that project (see Related Projects).

Our previous work (Bennett et al. 1995, Bennett et al. 2002, Bennett 2004) provides a solid foundation for the proposed monitoring program. We have carefully examined the ecology and potentially critical points in the life cycle (Figures 1,2), readily distinguished the effects on fish condition of poor feeding success from those of exposure to toxic chemicals (Figures 5), and then assessed potential consequences for growth rate and mortality ((Figures 6, Bennett 2004). In addition, we will be able to link the indicators of feeding success with information on actual diet and composition of the ambient food supply. Finally, by combining this approach with otolith microchemistry we can trace back through time and identify the region in which each individual was spawned and reared until it was caught in field sampling (Figure 7). This novel approach will also provide the information necessary to track the potential benefits from ecosystem restoration at the sub-regional and population levels.

The relationship among the studies, the measurements made in each, and the individual and population responses to the environment are shown in Figure 4. Again, the objective is to capitalize on the fact that measurements identifying population responses can only be made on individuals at different life stages. When this information is then summarized over regions and the entire habitat it can provide the most effective avenue for assessing the relevance of habitat restoration at a variety of scales, especially at the population level. In other words, we will proceed from what we can reliably measure to what matters for the population (and the species), as well as the concerns of management.

We propose to include an integrated suite of monitoring studies into the IEP surveys that estimate delta smelt abundance (Figures 3,4). Feeding studies will characterize the ambient food supply where fish are caught, and their gut contents will provide a link between local food production and its benefit to individuals. Histopathology studies will then provide us with crucial information on the extent to which growth is influenced by the feeding environment or by exposure to toxic chemicals in the ambient waters. Otolith studies will then measure the actual rate of growth over time periods of days to weeks. Otolith microchemistry will be used to identify the regions where individuals were born and lived until capture. All of this information will then be synthesized with estimates of abundance, as well as the fraction of fish entrained at the water export facilities, both based on data collected by the IEP. This will provide a comprehensive understanding of the regional contribution to annual population abundance, the mechanisms underlying regional performance, as well as the natal regions where fish are most susceptible to entrainment in the export facilities. This is the most technologically feasible way to understand the potential value of local habitat restoration actions for the delta smelt population.

We request three years of funding to implement this interdisciplinary monitoring program that will be composed of four integrated components (Tasks):

Task 1 – Fish sampling, growth and natal history (Bennett, Hobbs)
Task 2 - Measures of fish condition using bioassays and histopathology biomarkers (Teh)
Task 3 – Estimates of food availability and egg production (Kimmerer, Bennett).
Task 4 - Integration and data analysis (Bennett and collaborators)

Task 1: Fish Sampling, growth and natal history (Bennett, Hobbs).

Fish Sampling. Field specimens will be collected in cooperation with the ongoing IEP monitoring surveys and from efforts at the restoration sites as they get underway. With the IEP, delta smelt will be obtained from four surveys targeting different life stages:

- Spring Kodiak Trawl spawning survey (SKT)
- Spring post-larval survey (20mm)
- Summer juvenile Tow-Net Survey (TNS)
- Fall Mid-water Trawl survey (MWT)

In each survey sampling occurs approximately bi-weekly over a 2-4 month period, except that the MWT survey is monthly. Each survey encompasses nearly the entire distribution of delta smelt at the targeted life stage. Maps showing the distribution of sampling stations for each survey are available at the website for the Central Valley, Bay-Delta Branch, California Department of Fish and Game (http://www.delta.dfg.ca.gov/). Our objective will be to collect approximately 100 specimens from each survey by accompanying IEP personnel in the field. Where possible, samples will be weighted towards monitoring stations near the restoration sites, although strong tidal dispersion in the pelagic habitat of delta smelt implies that the regional scaling may be the most appropriate spatial scale for investigation.

Actual sample sizes and their geographic distribution will be proportional to sampling success, which is influenced by delta smelt distribution and therefore strongly influenced by climatic conditions. Overall, delta smelt cannot tolerate salinities above 19 psu or temperatures above 25^{o}C; over 90% of the fish occur below salinities of 9 psu and temperatures below 22^{o}C (Bennett 2004). Thus, in normal to wet conditions, delta smelt are more evenly distributed throughout their range, occurring as far west as the Napa river, whereas in dryer years their distribution is centered in the North Delta and lower Sacramento river (Table 1). Distribution also changes with life stage, with older life stages generally being more widely dispersed. Thus, we anticipate that the approximate proportions of samples from each region and life stage, and hence the potential contribution of each region, will fluctuate depending on climate, as outlined in Table 1. Fish will also be obtained from local sampling at restoration sites as those local monitoring efforts get underway.

During the TNS, MWT, and SKT surveys delta smelt are first identified and measured by IEP personnel. We will then weigh and decapitate them. Heads will be placed in 70% ethanol (ETOH) for later examination of otoliths, and bodies will be fixed in a buffered formaldehyde solution for histopathological evaluations and gut contents. Additional samples may be preserved using alternative fixation techniques, kept cool on ice, or frozen in liquid nitrogen. Water samples will also be taken during fish sampling to validate micro-chemical signatures found in the otoliths, and refine our current spatial resolution. In the 20mm survey, fish are often too small to accurately identify or decapitate onboard, so samples will be split between containers with ETOH and formaldehyde solution, or an additional net sample will be taken at each site. We will also obtain specimens in cooperation with salvage operations at the State and Federal Water Project (Dept. of Water Resources, U.S. Bureau of Reclamation). This overall sampling strategy is cost-effective, extending the value of existing resources and minimizing the sacrifice of additional fish.

<u>Fish Growth and Natal History</u> **-** Delta smelt growth will be evaluated by measuring incremental change in larval and juvenile otoliths (Secor et al. 1991). In our previous work we tailored this methodology for delta smelt, successfully validating the daily periodicity of otolith formation between known-age and field-caught specimens and developed models for back-calculating the size of the fish at ages prior to capture (Hobbs et al. 2004b). Verification of ring-counting by 2 independent readers indicates our methods are accurate to within 4-5 days for juvenile specimens. We also successfully evaluated over 300 juvenile otoliths from the field. In brief, otoliths are removed by micro-surgical technique, coded, secured to a glass slide, polished, and

analyzed using light microscopy aided by computerized image analysis. Digitized photographs of each otolith are archived for future use. Adult otoliths, however, are difficult to evaluate, because somatic growth and otolith deposition rate drops off markedly in the adult stage, therefore we are currently evaluating use of otolith weights and morphometrics to establish alternative ways to reliably age older individuals.

Chemical elements incorporated into otoliths as they form provide us with a powerful tool for identifying natal habitats and migration routes for delta smelt (Campana 1999). These elements include trace levels of rare earth and heavy metals dissolved in the waters surrounding the fish. Spatial differences in the concentrations of trace elements and heavy metals, and isotopic ratios of various elements have been well documented in the San Francisco Estuary (Ingram and Weber 1999, Hobbs et al. 2004a). Unique combinations of these signals can be recorded as otoliths form in different regions of the estuary. We have recently developed state-of-the-art technology to measure micro-chemical differences in otoliths for delta smelt (Figure 7, Hobbs et al. 2004a). Trace levels of elements within the otoliths are measured using Laser Ablation techniques in which a laser is focused on a minute portion of the otolith (5 μm diameter) to vaporize it. The vapor is transported into a mass spectroscopy instrument, and the concentrations of elements are measured. Measurements taken at the core of the otolith provide the micro-chemical signature of the natal habitat, whereas transects across the otolith can provide daily resolution of habitat use at the regional scale. Water samples will also be taken to further characterize and refine differences in elemental chemistry among regions.

Task 3: Ambient Bioassays and Histopathology (Teh)

Histopathology of fish organs and tissues provides us with an effective screening tool for assessing mechanisms influencing delta smelt condition or health (Hinton et al 1992, Teh et al 1997). We have successfully used this technique to distinguish the influences of poor feeding success from exposure to toxic chemicals in larval striped bass (Bennett et al. 1995) as well as delta smelt (Figures 5,6 , reviewed in Bennett 2004). A full assessment of potential chemical exposure is difficult and very expensive and therefore beyond the scope of monitoring.

Assessment of livers and gonads of bioassay survivors and field specimens by histopathology is well documented as a technique for determining characteristic signatures of alteration due to poor feeding and sub-lethal toxicity (Hinton et al., 1992, McCarthy and Shugart, 1990, Bennett et al. 1995, Teh et al., 1997). The primary advantage of this approach for our monitoring program is that it can distinguish the effects of food shortages from exposure to sub-lethal concentrations of contaminants on growth (abnormalities in the liver) and reproduction (abnormalities in the gonads) (Bennett et al. 1995).

We will employ both quantitative and qualitative histopathological techniques on about 400-500 specimens each year using methods described in Bennett et al. 1995; Teh et al 1997). Histology will be performed using whole larval specimens, because they can be embedded and sectioned (Bennett et al. 1995), and for key organs and tissues of older smelt, focusing initially on the liver and gonads where poor feeding and toxic chemicals produce effects (Teh et al. 2004b). Essentially, poor feeding depletes liver hepatocytes of energy reserves (glycogen), whereas exposure to toxic chemicals typically produces a variety of other alterations, including cancerous lesions. All relevant tissues will be analyzed and qualitatively scored based on severity of gylcogen depletion or other cellular abnormalities (e.g., 0= normal; 10= mild or less than 10% of the organ is affected; 20= moderate or 10-50%; and 30= severe or > 50%). Further clarification of liver and gonad diagnoses will be made on subsets of specimens using electron microscopy to determine the nature and extent of cellular and organelle alterations (Bennett et al. 1995). In addition, a small number of field-caught fish will be frozen in liquid nitrogen for further analyses of stress proteins (hsp70), fatty acid composition, and glycogen level.

Bioassays will be used to evaluate long-term influences of sub-lethal effects. In particular, we will use them to gauge the temporal responses of fish organs and tissues to poor feeding or exposure to a toxic chemical. This will provide us with standards to sharpen our histopathological diagnosis of field-caught specimens and allow us to more accurately align information with changes in growth and fish location through time. Larval and post-larval delta smelt will be obtained through the delta smelt culturing project (Baskerville-Bridges UCD, *personal communication*) and brought to the Aquatic Toxicology Program laboratories at University of California-Davis (UCD). Fish will be raised in flow-through systems at the Center for Aquatic Biology and Aquaculture, UCD. Water temperature will be maintained at $19 \pm 2\ ^{0}$C with flow rate at 2 L/min.

Three types of bioassays will be performed: (1) fish will be kept for 4 weeks in different treatments with alternating schedules of feeding or food-deprivation lasting for 1 week. (2) fish will be exposed to environmentally relevant concentrations of commonly used pyrethroid pesticides (esfenvalerate and permethrin) for 96 hours in a static beaker system according to the method of Teh et al. 2004a, b. Surviving fish will then be divided into fed or starved feeding treatments for 1 week followed by a normal feeding regime for 4 weeks. (3) Fish will be fed or starved for 1 week then divided into pesticide exposure treatments for 96 hr, followed by normal feeding regime for 4 weeks. In all bioassays, fish will be sampled at 0, 1, 2, 3, and 4 weeks for cumulative mortality, morphological anomalies, glycogen and lipid, stress proteins, histopathology, and growth determinations. Water quality parameters will also be recorded.

Task 5: Food availability and Egg Surveys (Kimmerer)

Gut content analysis is the more traditional of our studies, but it provides information on the actual feeding of the delta smelt that cannot be determined in any other way. The time scale of gut content analysis is the shortest of any of our studies, on the order of hours, responding sharply to the ambient food environment. It is also necessary to describe the ambient food environment, which will enable us to estimate food selectivity (which we have found is difficult to determine in the laboratory on these fish), and also allow us to extrapolate feeding conditions to places and times where smelt are not observed.

Smelt for feeding studies will be collected as described under Task 1. Guts will be carefully dissected from fish to be used for histopathological analysis. All prey items from each gut will be dissected out, identified to the lowest taxonomic resolution, and measured if possible. We will also explore using molecular markers to identify common prey items, which may enable us to process gut contents more rapidly and efficiently if suitable markers can be found. Most of the prey will probably be copepods, which are usually relatively identifiable because their hard parts resist digestion, and because the species diversity in the LSZ is low. We believe that species-specific differences in prey are very important to feeding success, and therefore will be at great pains to identify as many prey items to species as possible.

Plankton samples will be taken concurrently with the samples for delta smelt. The 20mm survey already takes plankton samples using a 10-cm Clarke-Bumpus net attached to the larger net frame. IEP would no doubt be happy to have us count the samples. Arrangements will be made to take plankton samples in conjunction with the other surveys from which gut contents will be analyzed. All of these data will be placed in context using data from the long-term IEP zooplankton monitoring program (1972 – present; e.g., Orsi and Mecum 1986, Kimmerer and Orsi 1996, Kimmerer 2004).

Egg survey. We also propose a pilot study to attempt to determine the distribution, abundance, and substrate of delta smelt eggs. This study, if successful, will pave the way toward surveys to obtain the most directly relevant abundance data possible for delta smelt: unequivocal estimates of reproductive output, combined with location and timing of that output that will be invaluable in establishing the most effective actions under the Environmental Water Account. Knowing where the eggs are will also help in designing and constructing habitat restoration to maximize benefits to delta smelt.

The pilot study will be conducted in the Napa River during a suitably wet year. We will work closely with the scientists conducting the Kodiak Trawl Survey to determine where and when the pre-spawning and post-spawning adults are found in this region. We will target these places and times with an intense sampling program. Samples will be taken using a variety of gears, depending on the substrate being sampled, including grabs and dredges and, in water less than 1 m deep, the hands of snorkel divers. Sampling will be stratified by depth and substrate, both of which will be determined in advance using results of previous Kodiak Trawl Surveys to establish the likely bounds of the spawning area. Estimates of the density of spawning fish and their fecundity will be used to determine the average density of eggs under the assumption that the fish spawn preferentially on one substrate type and depth region. This will provide us with estimates of the probability of collecting an egg in a sample of a given type, assuming some degree of spatial contagion. Using various degrees of spatial contagion we can then estimate the number of samples needed to quantify spawning on a given substrate if it is used, or rule it out if it is not.

This pilot study will be conducted with the help of numerous graduate students, all of whom will be familiar with field sampling principles and techniques. In addition, we will explore the use of science teachers or members of the lay public to help with this work. This will enable us to apply the intense sampling effort that we believe will be needed for this study, and also provide considerable educational benefit.

Relationship to other studies

One current studies and several to be proposed link closely with the work described here:

"Feeding Success of Delta Smelt" (Kimmerer and Bennett, IEP funding, work in progress): We are examining the population dynamics of two copepod species that appear to be important food resources for delta smelt, and along with the timing and degree of food limitation in delta smelt. Total copepod biomass has declined since the late 1980's, and we are trying to understand how the seasonal pattern of these copepods interacts with the feeding requirements of delta smelt. This is the topic of an ongoing Master's student project at SFSU, and it will provide a perfect springboard for the feeding studies to be conducted in this proposed project.

"Modeling the delta smelt population" (Kimmerer, Bennett, and K. Rose, LSU; proposal planned to CALFED Science Program). We will be proposing a series of models including matrix models and an individual-based model to extend our field- and lab-based understanding of the biology of this fish. The individual-based model in particular will benefit greatly from the individual-based information developed in this project.

"Foodweb support for the delta smelt population" (Kimmerer and colleagues at SFSU; proposal planned to CALFED Science Program). Our preliminary results suggest that delta smelt are frequently food limited. We are proposing to investigate the extent to which food limitation could be eased through management actions in the Delta, including nutrient management and flow conditions.

6. Feasibility:

Our research plan is feasible; each of the collaborators is an expert in their discipline of proposed work, and all have a successful background in interdisciplinary collaborative projects. The methods to be applied are already in use, or have been used in the past, and will be refined during the course of the project. A letter of support from the IEP also acknowledges collaboration with the IEP fish monitoring surveys (Appendix B). Feasibility will be further enhanced because we will be capitalizing on the use of fish that will be killed as a result of abundance monitoring, and thus will be considered as "take" under the IEP Endangered Species Act collection agreement with U.S. FWS. Bennett and students hold current State collecting permits and have been working with U.S. FWS to obtain a Federal permit for archiving delta smelt specimens over the last year. Currently, all specimens are housed at UCD under a Federal permit issued to Dr. P.B. Moyle.

7. Expected Outcomes and Products:

We anticipate the following products from the proposed work:
1.- Periodic oral presentations and peer review at IEP Estuarine Ecology Team and CALFED workshops. In particular, the Environmental Water Account has held a delta smelt workshop

each of the last 4 years, and delta smelt research receives close attention at the annual scientific review panel meeting convened by the CALFED Lead Scientist.
2.- Annual reports to CALFED summarizing progress.
3.- Final report to CALFED summarizing results.
4.- Several publications in peer-reviewed journals.

8. Data Handling, Storage, and Dissemination:

Data developed during this project will be stored in databases on computer disks. Digital photographs of each otolith evaluated will be stored on CD-ROM. A database of all delta smelt specimens in our collection is being maintained in ACCESS. This contains relevant information on collection date and location, as well as types of evaluations performed on individual specimens. In addition, relevant data on individual condition, zooplankton abundance, and feeding will be placed in the IEP database after publications are submitted.

9. Public Involvement and Outreach:

In addition to regular communications with IEP, CALFED, and stakeholders, we will explore the use of science teachers or members of the lay public to help with local monitoring at restoaration sites and the pilot egg survey.

10. Work Schedule:

Our proposed work schedule is outlined in Figure 8. (*Task 1*) Bennett will begin project planning in early 2005. We will then convene a project meeting to organize the work-plan and discuss project products. Field sampling will then begin with the IEP KTS in early spring. Otolith analyses will begin soon after the first samples are collected and continue throughout the year. Sampling will continue into June each year with the 20mm survey, and then in August with the TNS and September with the MWT. Sampling for adults will then occur in November or December with the MWT each year. (*Task 2*) Teh's research team will begin with histopathological analyses soon after field sampling begins and continue throughout the year. The bioassays will be conducted in late spring in year one and two concurrent with the production schedule of delta smelt in the culturing facility. (*Task 3*) Kimmerer's team will begin gut analyses and plankton sampling in early April with the 20mm survey and this will continue throughout the duration of the project. The pilot egg survey will occur in one (wet) year with high outflow conditions (Napa river) in conjunction with the KTS. *(Task 4)* Bennett will convene at least 2 group meetings each year (probably in February and September) with all researchers associated with the project, as well as agency collaborators, to review progress, data synthesis, and discuss publications in preparation. Bennett and Kimmerer will present finding at CALFED EWA workshops, and annual reports will be presented to CALFED and IEP each October. All collaborators will provide input for the final report to be completed within 3-months after the project deadline.

B. Applicability to CALFED Bay-Delta Program ERP Goals, the ERP Draft Stage 1 Implementation Plan, and CVPIA Priorities.

1. ERP and CVPIA Priorities:

Our proposed work plan is central to several CALFED ERP Strategic Goals and priorities. The first Goal of the ERP is to "Achieve recovery of at-risk native species dependent on the Delta and Suisun Bay….." The Draft Stage 1 Implementation Plan states "The recovery of at-risk species is at the heart of the ERP." Delta smelt is at the heart of the at-risk species: it is clearly both the most at-risk native species in this region, and the most dependent on the Delta and Suisun Bay. To achieve recovery requires an understanding of how different actions contribute to recovery; thus, the degree of specificity incorporated in our proposed project is essential for determining how and where this recovery may be achieved, and for assessing progress.

Relevant priorities of the CVPIA include: "to protect, restore, and enhance fish, wildlife, and associated habitats in the Central Valley and Trinity River basins of California; to address impacts of the Central Valley Project on fish, wildlife and associated habitats;…to contribute to the State of California's interim and long-term efforts to protect the San Francisco Bay/Sacramento-San Joaquin Delta Estuary." All of these point to the need for attention to delta smelt.

Although the Environmental Water Account (EWA) is not part of ERP, there is a growing linkage among ERP, EWA, and CVPIA, which are becoming viewed as a comprehensive package designed to reduce conflicts over effects of water projects on key fish species. The EWA is increasingly focused on delta smelt, which appear to be more vulnerable to effects of export pumping than any of the other species of concern. An improvement in our understanding of vulnerabilities of delta smelt from different regions to export pumping should help sharpen the focus of EWA to those times of greatest effectiveness.

2. Relationship to Other Ecosystem Restoration Actions, Monitoring Programs, or System-wide Ecosystem Benefits:

Our proposed monitoring program will be integrally linked with the IEP and CALFED Science programs efforts to restore delta smelt. The overall approach and design of our program may be transferred and tailored for other aquatic species in the Sacramento-San Joaquin Watersheds and San Francisco Estuary.

3. Additional Information for Proposals containing Land Acquisition:

N/A

B. Qualifications

Organizational structure. Bennett will serve as project leader and coordinate with the supervisors and boat captains of the IEP sampling surveys, and personnel at the fish salvage facilities. Bennett and Kimmerer will regularly discuss project findings and obtain feedback from the IEP Estuarine Ecology Team and CALFED ERP and Science programs. Collaborator responsibilities will closely follow their respective task descriptions and work schedule.

Dr. William A. Bennett received B.S. and Master's degrees in population biology from the University of Massachusetts at Boston, and Ph.D. in ecology from the University of California at Davis (UCD). Dr. Bennett has been a Postdoctoral Researcher at the Bodega Marine Laboratory and is currently an Assistant Research Ecologist with the John Muir Institute of the Environment and faculty member of the Graduate Group in Ecology at UCD. Bennett has worked over 15 years on the ecology of fishes in the San Francisco Estuary, including survival of larval and adult striped bass, exotic inland silversides, the vertical migration behavior of larval fishes. Since arriving at UCD he has worked closely with the Interagency Ecological Program (IEP). He is an active member of IEP's Estuarine Ecology Team, Entrapment Zone Study Team, and Contaminant Effects Team. Recently, Dr. Bennett authored the CALFED white paper on delta smelt, currently in review for San Francisco Estuary and Watershed Science. He was also the co-technical program chair for the first CALFED Science Conference.

Dr. Wim J. Kimmerer received his B.S. degree in chemistry from Purdue University and his Ph.D. in biological oceanography from the University of Hawaii. After positions at the Hawaii Institute of Marine Biology, University of Melbourne, and BioSystems Analysis Inc., an environmental consulting firm, he became a Senior Research Scientist at the Romberg Tiburon Center, San Francisco State University. Dr. Kimmerer's expertise is in marine and aquatic ecosystems, including physical, chemical, and biological oceanography, ecology of estuaries and lagoons, fisheries management, simulation modeling, and statistical analysis of data. His current research interests include estuarine ecology, zooplankton ecology, population dynamics of fish such as salmon and striped bass, and the effect of anthropogenic influences such as freshwater flow on estuarine and marine systems. Dr. Kimmerer has written over 80 papers and technical reports on these and related topics, including the draft CALFED White Paper on Open Water Processes. He has been closely involved with the Interagency Ecological Program, acting as chair of the Estuarine Ecology Team and the Entrapment Zone study team. He was a member of the CALFED Ecosystem Restoration Program Core Team, developing a strategic plan for the program, and is now a member of the Independent Science Board.
Note regarding conflicts: Kimmerer has a potential conflict of interest in that he is a member of the CALFED ERP Science Board, and an advisor to the CALFED Lead Scientist on the Environmental Water Account. The Science Board position has been determined by CALFED's attorney not to constitute a conflict provided the member does not actively participate in development of the Implementation Plan, or in the evaluation of proposals. Kimmerer has not been involved in these activities.

Dr. Swee J. Teh, is a research toxicology and pathology faculty-member at UC Davis, Dept. of Anatomy, Physiology and Cell Biology and has over 15 years of extensive field and laboratory research experience in ecotoxicology and biomarker studies. His research interests are in the fields of developmental biology, nutrition, toxicology and pathology with special emphasis on adverse health, reproductive, and embryonic developmental effects of environmental endocrine disruptors and contaminants in invertebrate, fish and shellfish populations. He has publications, and travels nationally and internationally presenting talks and workshops in this area.

Dr. James A. Hobbs received a B.S. degree in Marine Biology from Sonoma State University, and recently completed a PhD. in Ecology from the University of California, Davis. Dr. Hobbs's dissertation research focused on development of otolith microstructure and microchemistry techniques to understand the population biology and ecology of delta smelt. He has been working with Dr. Bennett on San Francisco Bay Estuary issues for 9 years, and has been a frequent participant in the Estuary Ecology Team and Resident Fishes Team. Dr. Hobbs has presented his research findings at numerous local, national and international conferences. Dr. Hobbs has a publication in review with the Journal of Marine and Freshwater Research outlining the state of the art use of strontium isotopes in delta smelt otoliths to identify the natal origin of delta smelt, and served as the chair of a poster session showcasing the use of otoliths in fish ecology and restoration issues in the San Francisco Estuary at the "State of the Estuary Conference" and "CALFED Science Conference 2004. His current research interests focus on the application of otolith based research studies to understand the population ecology of estuarine species and how key processes in the demographics are associated with habitats and restoration activities.

D. Cost

1. Budget

The budget requirements are submitted on-line.

2. Cost sharing

No cost-sharing is required.

3. Long-term funding strategy

Request funds for subsequent phases of the project from CALFED and other funding sources.

E. Compliance with Standard Terms and Conditions

The University of California, Davis takes exception to the following proposed "standard" clauses:

Exhibit A – Scope of Work Section III, Project Officials (add Administrative Contact)

Exhibit B – Attachment 3 – State Travel & Per Diem Expenses Guidelines (Delete)
Exhibit C – General Terms and Conditions for ERP Grants (Replace with GIA 101)
Exhibit D – Special Terms and Conditions for ERP Grants (Replace with UC IP Clause)

Please note with the exception of Exhibit A the above has previously been negotiated with CALFED/GCAPS on behalf of the University of California and agreeable language has been included in the following current ERP agreements with UC Davis (ERP-02D-P31, ERP-02D-P32, ERP-02D-P33, ERP-02D-P35, and ERP-02D-P51).

Exhibit A – Scope of Work, Section III, Project Officials. We request that a third individual be added as the administrative contact and will act on behalf of the Grantee in lieu of the Project Director.

F. Literature Cited

Bennett, W.A. 1996. Framework for evaluating pesticide effects on fish populations. IEP Newsletter 8:7-12 (Spring 1996).

Bennett, W.A. 2004. The population ecology of delta smelt in the San Francisco Estuary, California. *Submitted to* San Francisco Estuary and Watershed Science [CALFED online serial].

Bennett, W.A. and P.B. Mole. 1996. Where have all the fishes gone?: factors producing fish declines in the San Francisco Bay estuary. In, San Francisco Bay the urbanized ecosystem. J.T. Hollibaugh, editor. AAAS Symposium volume.

Bennett, W.A., D.J. Ostrach, and D.E. Hinton. 1995. Condition of larval striped bass in a drought- stricken estuary: evaluating pelagic food web limitation. Ecological Applications 5: 680-692.

Bennett, W.A., W.J. Kimmerer, and J.R. Burau. 2002. Plasticity in vertical migration by native and exotic estuarine fishes in a dynamic low salinity zone. Limnology and Oceanography 47: 1496-1507.

Bouley, P.B. 2004. The feeding ecology of a highly abundant copepod, *Limnoithona tetraspina* (Oithonidae), in the San Francisco Estuary : Patterns of predation on natural prey assemblages. MA Thesis, San Francisco State University.

Brown, R. and W.J. Kimmerer. 2001. Delta Smelt and CALFED's Environmental Water Account. http://www.science.calwater.ca.gov/pdf/2001_Delta_Smelt_Workshop.pdf

CALFED 2000. Ecosystem Restoration Program Plan Strategic Plan for Ecosystem Restoration. http://calwater.ca.gov/programs/ecosystemrestoration/ecosystemvol3restorationplan.shtml

Campana, S.E. 1999. Chemistry and composition of fish otoliths: pathways, mechanisms and applications. Marine Ecology Progress Series 188: 263-297.

Cowan, J.H. K.A. Rose, and D.R. DeVries. 2000. Is density dependent growth in young-of-the year fishes a question of critical weight? Reviews in Fish Biology and Fisheries. 10:61-89.

Crepeau, K.L. and K.M. Kuivila. 2000. Factors controlling rice pesticide concentrations in the Colusa Basin Drain and the Sacramento River, California, 1990-1993, J. Environmental Quality, vol. 29(3): 926-935.

EWA Review Panel Summary. 2003. Review of the 2002-2003 Environmental Water Account (EWA) http://www.science.calwater.ca.gov/pdf/EWA_Panel_Report_2003.pdf

Grimaldo, L., R. E. Miller, C. M. Peregrin, and Z. P. Hymanson. 2004. Spatial and temporal distribution of native and alien larval fish assemblages in the southern Sacramento-San Joaquin Delta. In, F. Feyrer, L. Brown, J. Orsi, and R. Brown, eds. Early life history of fishes in the San Francisco Estuary and watershed. American Fisheries Society Symposium. Bethesda, Maryland.

Hinton, D.E., et al. 1992. Histopathological Biomarkers. In: Biomarkers: Biochemical, Physiological, and Histological Markers of Anthropogenic Stress. R.J. Huggett, R.A. Kimerle, P.M. Mehrle, H.L. Bergman (eds.) Lewis Publishers, Inc., Boca Raton, FL.

Hobbs, J.A., J. Burton-Hobbs, and W.A. Bennett. 2004a. The application of otolith strontium isotope ratios using MC-LA-ICPMS to determine natal areas for delta smelt (Hypomesus transpacificus) in the San Francisco Estuary, USA. Journal of Freshwater and Marine Research; 3rd International Otolith Symposium Proceedings. (*Submitted, in Review*) (Chapter in Ph.D. dissertation, Ecology Graduate Group, UC-Davis, October 2004).

Hobbs, J.A., J. E. Burton, W.A. Bennett, and B. Baskerville-Bridges 2004b. Age and growth validation of delta smelt (*Hypomesus transpacificus*) in the San Francisco Estuary. U.S. Fishery Bulletin. (*Submitted, in Review*) (Chapter in Ph.D. dissertation, Ecology Graduate Group, UC-Davis, October 2004).

Houde, E. 1987. Fish early life history dynamics and recruitment variability. American Fisheries Society Symposium 2:17-29.

Houde, E. D. 1989. Subtleties and episodes in the early life of fishes. Journal of Fish Biology 35:29-38.

Ingram, B.L., P. K. Weber. 1999. Salmon origin in California's Sacramento-San Joaquin river system as determined by otolith strontium isotopic composition. Geology 27: 851-854.

Kimmerer, W. J. 2004. Open water processes of the San Francisco Estuary: >From physical forcing to biological responses. San Francisco Estuary and Watershed Science [online serial].

Vol. 2, Issue 1 (February 2004), Article 1.

Kimmerer, W. J., and J. J. Orsi. 1996. Causes of long-term declines in zooplankton in the San Francisco Bay estuary since 1987. Pages 403-424 *in* J. T. Hollibaugh, editor. San Francisco Bay: The Ecosystem. AAAS, San Francisco.

Kimmerer, W.J. and R. Brown. 2003. CALFED Bay-Delta Program Environmental WaterAccount Summary of the Annual Delta Smelt Technical Workshop, Santa Cruz, CA, August 18-19, 2003. http://www.science.calwater.ca.gov/workshop/water_ops_symposium.shtml

Kimmerer, W. J., E. Gartside, and J. J. Orsi. 1994. Predation by an introduced clam as the likely cause of substantial declines in zooplankton of San-Francisco Bay. Marine Ecology-Progress Series 113:81-93.

Kimmerer, W.J., J.H. Cowan Jr., L.W. Miller, and K.A. Rose. 2000.Analysis of an estuarine striped bass population: Influence of density-dependent mortality between metamorphosis and recruitment. Can. J.Fish. Aquat. Sci. 57: 478-486

Kuivila, K. M., and C. G. Foe. 1995. Concentrations, transport and biological effects of dormant spray pesticides in the San Francisco estuary, California. Environmental Toxicology and Chemistry **14**:1141-1150.

Lott, J. 1998. Feeding habitats of juvenile and adult delta smelt from the Sacramento-San Joaquin estuary. IEP Newsletter 11:14-19.

McCarthy, J.F. and Shugart L.R. 1990. Biological Markers of Environmental Contamination. In: Biomarkers of Environmental Contamination. Lewis Publishers, CRC Press, Inc., Boca Raton, Florida, pp. 3-14.

Moon, G.E., K.M. Kuivila, C. Ruhl, and D.H. Schoelhamer. 2000. Exposure of Delta Smelt to dissolved pesticides in 1998 and 1999, IEP Newsletter, 13 (4): 27-33.

Nobriga, M. 1998. Evidence of food limitation in larval delta smelt. IEP Newsletter 11: 20-23.

Nobriga, M. 2002. Feeding ecology of larval delta smelt: a multi-year assessment of diet composition and feeding incidence in relation to environmental and ontogenetic influences. California Fish and Game. 88: 149-164.

Orsi, J., and W. Mecum. 1986. Zooplankton distribution and abundance in the Sacramento-San Joaquin Delta in relation to certain environmental factors. Estuaries **9**:326-339.

Orsi, J. J., and S. Ohtsuka. 1999. Introduction of the Asian copepods *Acartiella sinensis, Tortanus dextrilobatus* (Copepoda: Calanoida), and *Limnoithona tetraspina* (Copepoda: Cyclopoida) to the San Francisco Estuary, California, USA. Plankton Biology and Ecology 46:128-131.

Rose, K. A., J. H. Cowan Jr., K. O. Winemiller, R. A. Myers, and R. Hilborn. 2001. Compensatory density dependence in fish populations: importance, controversy, understanding and prognosis. Fish and Fisheries 2: 293-327.

Secor, D., J.M. Dean, E.H. Laban. 1991. Manual for Otolith Removal and Preparation for Microstructural Examination. Handbook for evaluation of fish otoliths. Belle Baruch Institute for Marine Biology and Coastal Research.

Teh, S.J., Adams, S.M. and Hinton, D.E. 1997. Histopathologic biomarkers of anthropogenic stress in resident redbreast sunfish (*Lepomis auritus*) and largemouth bass (*Micropterus salmoides Lac□p□de*) from contaminant impacted sites. Aquatic Toxicology. 37:51-70

Teh, S.J., Deng, X., Deng, D.F., Teh, F.C., Hung, S.S.O., Fan, W-M.T, Liu, J. and R.M Higashi 2004a. Chronic Effects of Dietary Selenium on Juvenile Sacramento Splittail (*Pogonichthys Macrolepidotus*). Environ. Sci. Technol.; 38(22) pp 6085 - 6093.

Teh, S.J., Zhang, G.H., Kimball, T, and F.C. Teh, 2004b. Lethal And Sublethal Effects Of Esfenvalerate And Diazinon On Sacramento Splittail Larvae. In F. Feyrer, L. Brown, J. Orsi, and R. Brown, eds. Early life history of fishes in the San Francisco Estuary and watershed. American Fisheries Society Symposium. Bethesda, Maryland.

Thompson, B. 2000. An overview of contaminant-related issues identified by monitoring in San Francisco Bay. Environmental Monitoring and Assessment 64:409-419.

H. Nonprofit Verification.

See Attachment A.

Table 1. Rough approximation of anticipated delta smelt sampling success (% fish) in years with high versus low freshwater outflow among regions of the San Francisco Estuary.

	Region							
	North Delta		Central Delta		Suisun Marsh		Napa River	
Monitoring Survey			Freshwater		Outflow			
	High	Low	High	Low	High	Low	High	Low
Spring Kodiak	30	80	30	10	25	10	15	0
20mm	25	80	25	10	25	10	25	0
Tow Net (TNS)	25	70	25	25	25	15	5	0
Mid-water trawl (MWT)	40	80	20	20	40	20	0	0

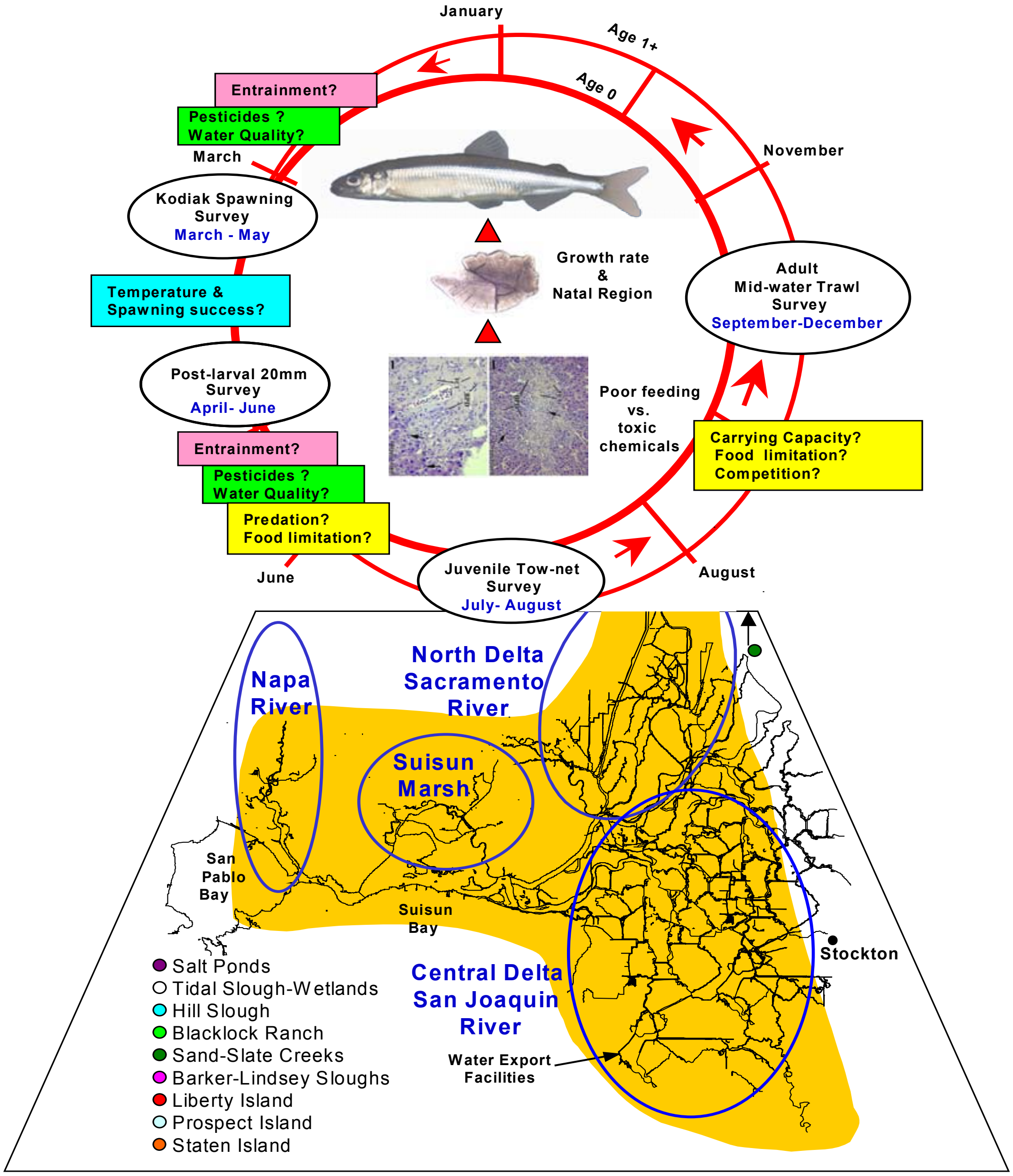


Figure 1. Delta smelt in space and time. A conceptual life cycle model shows key life stages to be monitored, the timing of factors influencing survival, and indivdually-based approach for measuring vital parameters from liver hepatocytes and otoliths for delta smelt. Also shown are the locations of nine restoration sites (colored circles) that propose benefits for delta smelt, as well as the natal regions (open ovals) identified by elemental signatures of otoliths within the range of the population (yellow shading) in the San Francisco Estuary.

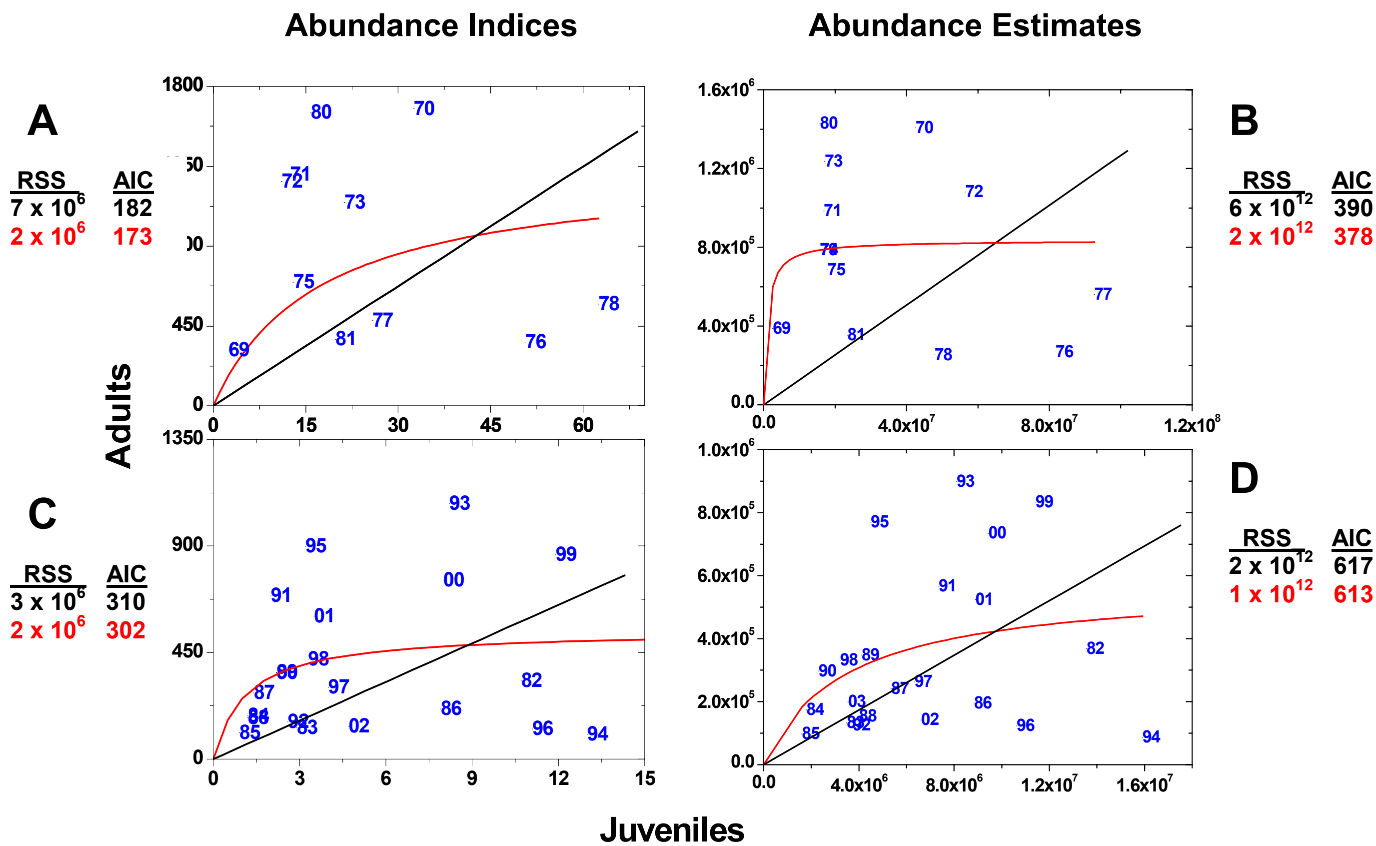


Figure 2. Stock-recruit relationships comparing fits of Beverton-Holt (density dependence) and linear (density independence) models using abundance indices and abundance estimates for the juvenile and adult stages. The period before the population decline (1967-1982) is shown (A, B) with similar fits for the post-decline period (C, D). Model fits are compared using the residual sum of squares (RSS) and Akaike's Information Criterion (AIC) where a lower values indicate the Beverton-Holt model provides a better fit to the data points than a linear model. Data points are shown as years (blue). (From, Bennett 2004.)

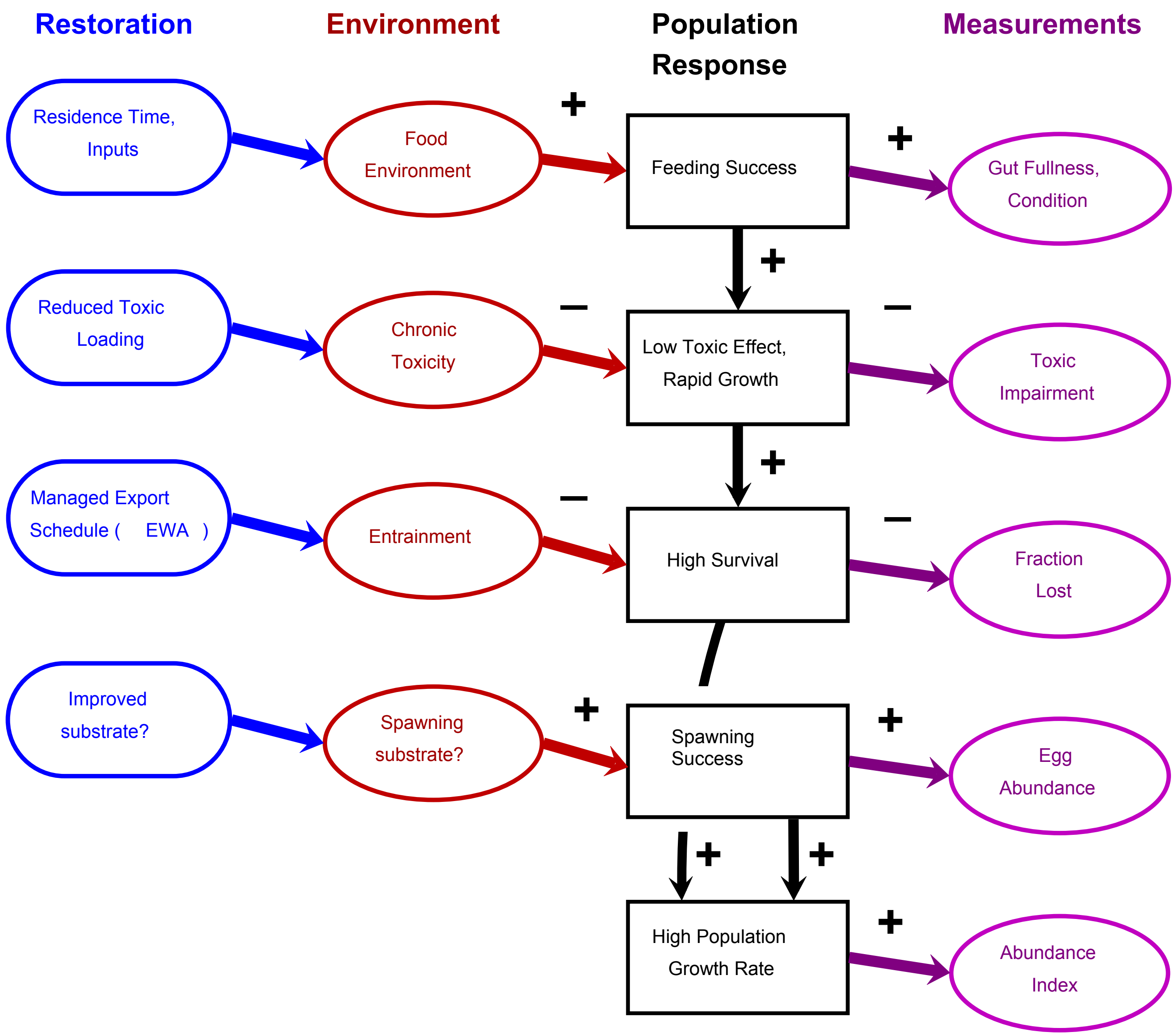


Figure 3. Conceptual model showing the pathways of potential effects resulting from restoration on the delta smelt population, and the measurements needed to monitor them in the San Francisco Estuary. Restoration actions that improve flow regimes or key nutrient inputs may influence the local production of food, improving feeding success, gut fullness, and liver condition promoting rapid growth rates for individuals. Reductions of toxic pesticide inputs would further improve growth leading to higher survival rates. Management of freshwater exports (e.g. use of the Environmental Water Account, EWA) would reduce the fraction of fish lost further increasing survival. Habitat improvements providing more spawning substrate may increase spawning success and egg abundance leading to higher growth rates for the population among years.

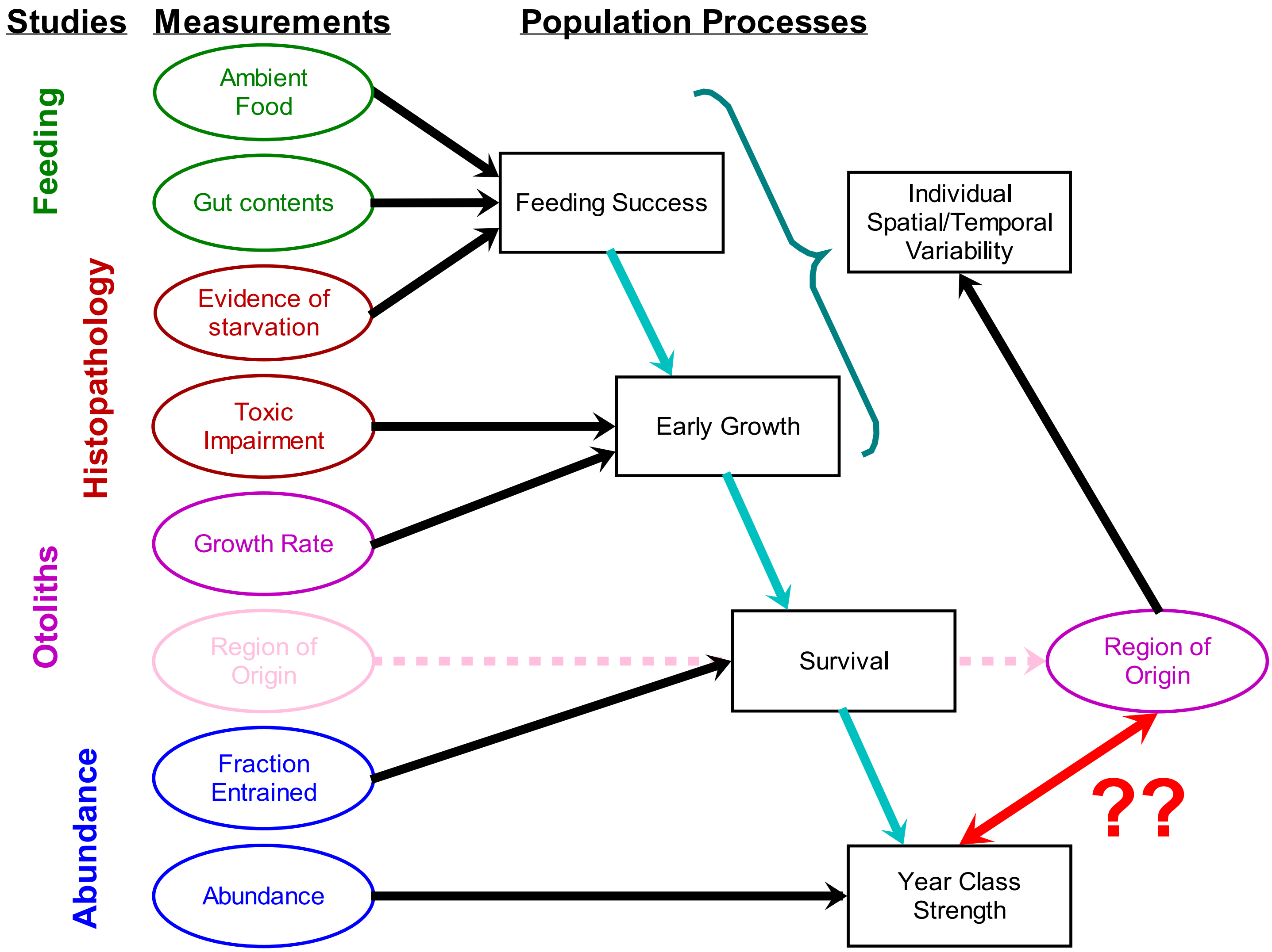
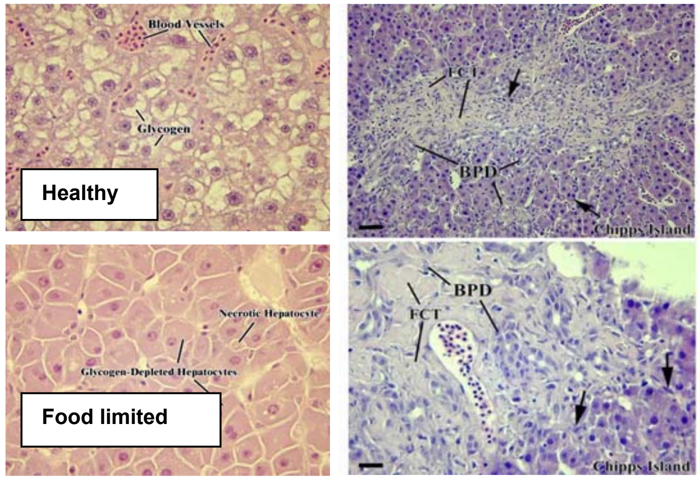


Figure 4. Logic of the monitoring design. Measurements to be made in this program and the IEP monitoring programs are listed in ovals on the left with the general category of studies, which map to the project tasks, in matching color at the far left. Black arrows indicate the population processes (in black) at which each measurement is directed. Most of the measurements focus on early life history. The feeding studies and one part of the histopathology study will determine feeding success; together with the remaining histopathology and otolith aging we will have a good idea of feeding, toxic compromise, and growth of each individual fish. Individual variability within and between regions where fish are collected will be determined. IEP monitoring efforts, listed in blue, determine abundance and the fraction of some life stages entrained at the south Delta export facilities. All of this information will be interpreted in terms of geography using the otolith microchemistry, used to place the individual data and entrainment data in a broader context. The principal question to be answered by this entire suite of techniques is how variability at the individual level, differing among regions, combined with differential exposure to entrainment in export pumps, translates into year-class strength and, conversely, to what extent year-class strength is determined by the observed regional pattern of variability.



Glycogen in liver (energy reserve)

Liver cancer from pesticide exposure

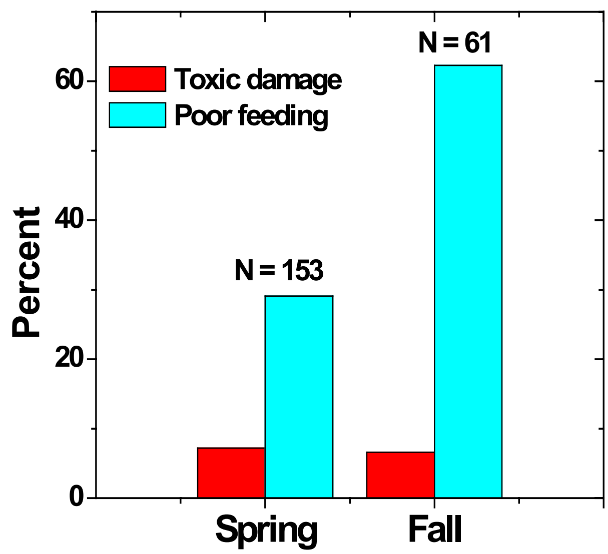


Figure 5, Histopathology of juvenile delta smelt livers. Photographs show differences between a healthy (glyocgen enriched; light areas in hepatocytes) liver versus a food deprived liver (few light areas in hepatocytes), and livers damaged by exposure to pesticides. Also shown are results from field specimens indicating percent of livers damaged by pesticides versus poor nutrition from 1999-2000 (Form, Bennett 2004).

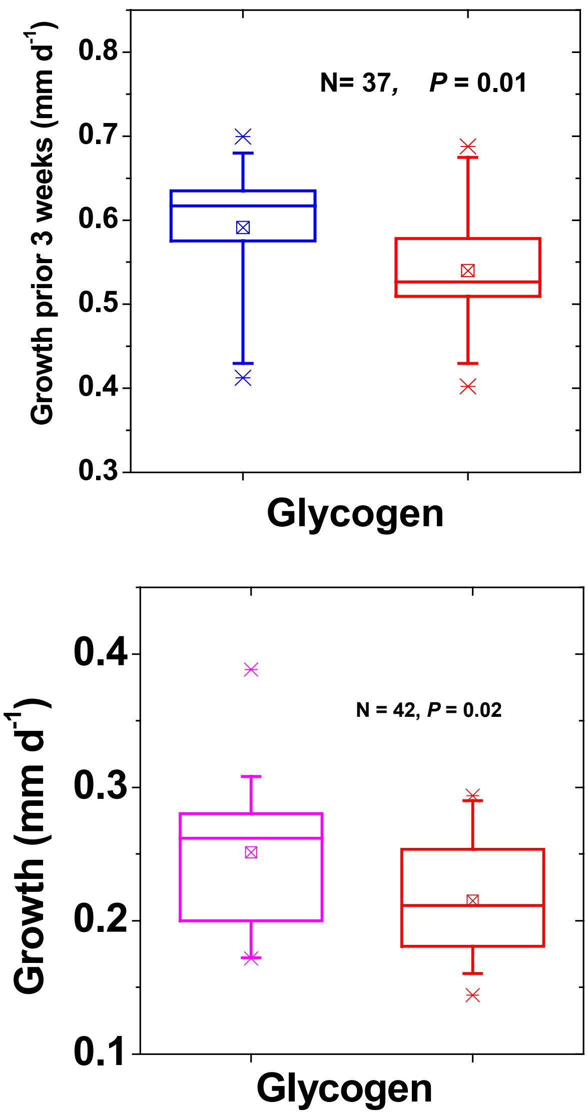


Figure 6. Relative growth during the 3 weeks prior to capture for healthy and undernourished juvenile delta smelt that had begun to feed exogenously when *E. affinis* declined in abundance during spring 1999 (upper panel). Similar relationship for juveniles in late summer (lower panel). Diagnosis of feeding condition was by histopathology of liver cells (From, Bennett 2004).

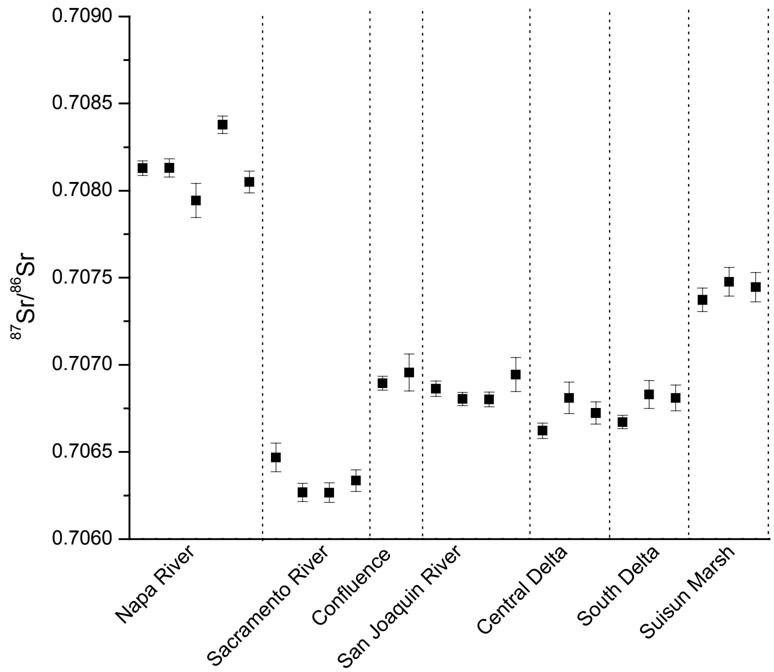


Figure 7. Differences in strontium isotope ratios ($^{87}Sr/^{86}Sr$) for individuals (2σ) collected at potential natal areas within the San Francisco Estuary.

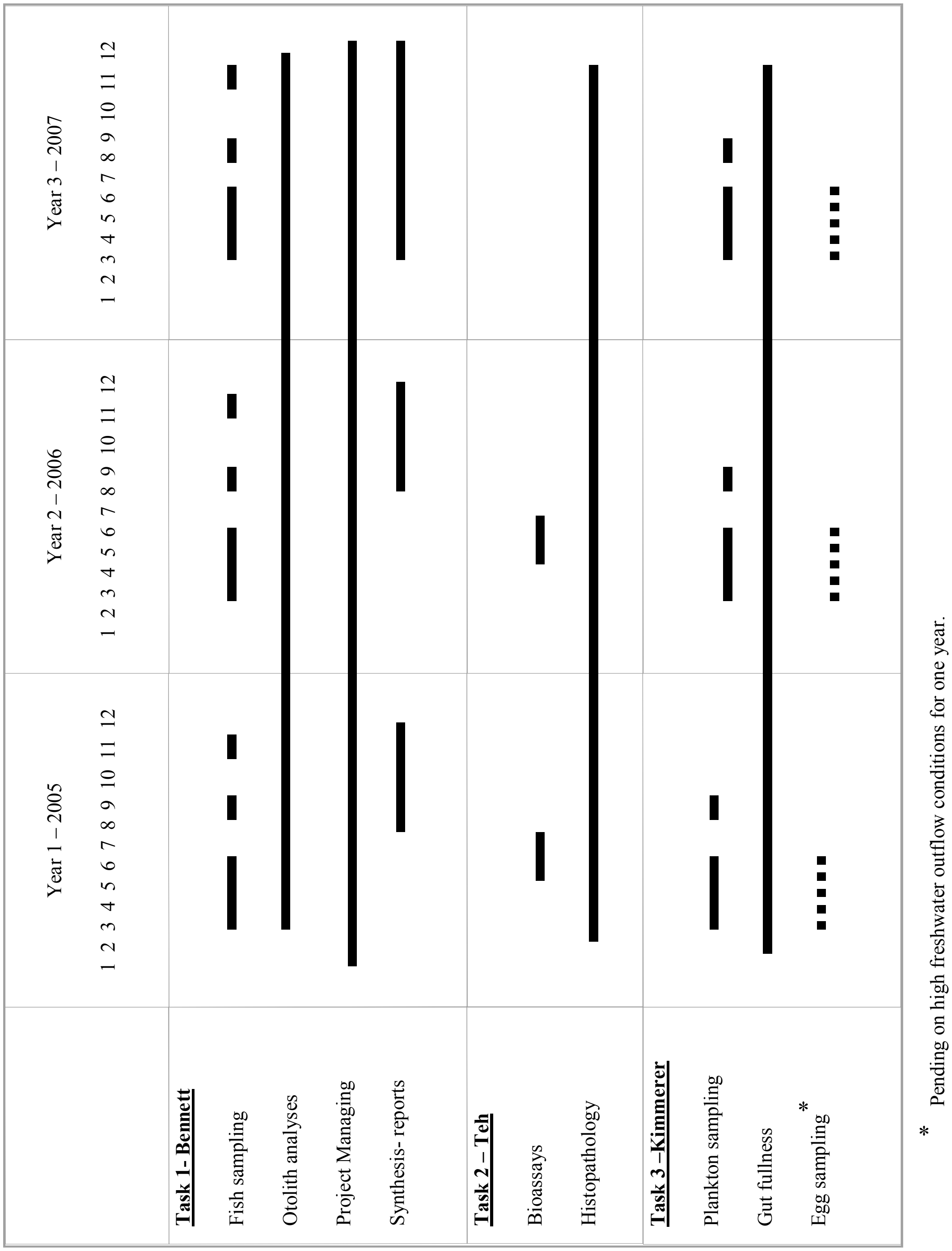


Figure 8. Work Schedule. Thick lines show the monthly course of work for each Task.

Internal Revenue Se(e Department (ie Treasury

Attachment A

District Director

450 Golden Gate Ave.
San Francisco, Calif. 94102

Person to Contact:
Desk Officer
Telephone Number:
(415) 556-5353
Refer Reply to:
EP/EO:1

Date:
8 SEP 1982

RECEIVED SEP 10 1982 OFFICE OF THE GENERAL COUNSEL

The Regents of the University of California
c/o The Office of the General Counsel
590 University Hall
2200 University Avenue
Berkeley, CA 94720

Re: Request for Confirmation of Exempt Status under Section 501(c)(3) of the Internal Revenue Code of 1954

Dear Regents:

This is in reference to your letter of July 13, 1982 requesting confirmation of the exempt status of The Regents of the University of California under section 501(c)(3) of the Internal Revenue Code of 1954.

In our letter of September 14, 1939, Code IT:P:T:1 CQ, it was held that you were entitled to exemption under the provisions of section 101(6) of the Revenue Act of 1938.

A determination or ruling letter issued to an organization granting exemption under the Internal Revenue Code of 1954 or under a prior or subsequent Revenue Act remains in effect until exempt status has been terminated, revoked or modified.

Our records indicate that you are the regularly constituted state university of the State of California originally created by a state legislature act of 1868; that you are engaged in educational activities; that your income is derived from investments, endowments, tuition, and miscellaneous sources; and that your income is used in furtherance of your educational activities.

In addition, it appears from our records (including the information submitted with your letter of July 13, 1982), that there has been no change in your organization's exempt status. Accordingly, our letter of September 14, 1939 is still in effect. This letter does not constitute a no change examination letter.

Because section 501(c)(3) of the Internal Revenue Code of 1954 was derived from and continues, without substantive change, the language of section 101(6) of the Revenue Act of 1938 ("1939 Code") and because our letter of September 14, 1939 is still in effect, it appears that you and your constituent units are entitled to exemption as an organization described in section 501(c)(3) of the 1954 Code.

Donors may deduct contributions to you as provided in section 170 of the Internal Revenue Code of 1954 (formerly section 23(0) of the Internal

The Regents of the University of California

Revenue Code of 1938). Bequests, legacies, devises, transfers, or gifts to you or for your use are deductible for Federal estate and gift tax purposes as provided in the applicable provisions of sections 2055, 2106, and 2522 of the Internal Revenue Code of 1954.

You are not required to file Form 990, Return of Organization Exempt from Income Tax, because you are a State institution, the income of which is excluded from gross income under section 115(a) of the Internal Revenue Code of 1954.

You are not required to file Federal income tax returns unless you are subject to the tax on unrelated business income under section 511 of the Code. If you are subject to this tax, you must file an income tax return on Form 990-T. This office has not been asked to consider and therefore, in this letter, we are not determining whether any of your present or proposed activities are unrelated trade or business as defined in section 513 of the Internal Revenue Code of 1954.

Because this letter could help resolve any questions about your exempt status, you should keep it in your permanent records.

If you have any questions, please contact the person whose name and telephone are shown in the heading of this letter.

Sincerely,

Michael Sassi

District Director

University of California
Systemwide Administration

Office of the
Assistant Vice President —
Business Management
Contracts and Grants Office

Memo

Operating Requirement

No. 83-33
December 2, 1983

VICE CHANCELLORS — BUSINESS AND FINANCE/ADMINISTRATION*
CONTRACTS AND GRANTS OFFICERS (NON-LAB)
SYSTEMWIDE ADMINISTRATION FUNCTIONAL MANAGERS

Subject: Exempt Status of The Regents of the University of California under Section 501(c)(3) of the Internal Revenue Code of 1954

The Internal Revenue Service made a determination in 1939 that The Regents of the University of California was tax exempt under Section 101(6) of the Internal Revenue Act of 1938. This was formalized in a letter to The Regents dated September 14, 1939 (see Enclosure 1).

Pursuant to a request by the Office of the General Counsel, the IRS has subsequently indicated in a letter to The Regents dated September 8, 1982 that the University continues to be exempt under Section 501(c)(3) of the Internal Revenue Code of 1954 (see Enclosure 2). Section 501(c)(3) was derived from, and continues without substantive change, the language of Section 101(6) of the Internal Revenue Act of 1938. This determination of the University's exempt status will remain in effect until the exemption has been terminated, revoked, or modified by the IRS.

Also, in a letter to The Regents dated November 23, 1973, the IRS has acknowledged that the University is not a private foundation within the meaning of Section 509(a)(1) of the IRS Code of 1954 (see Enclosure 3).

These letters from the IRS to The Regents may be provided to sponsors as certification of the University's tax exempt status.

Refer: Barbara Perry
(415) 642-2886
ATSS 582-2886

Subject Index: 13
Organization Index: U-115

David F. Mears

David F. Mears
University Contracts and
Grants Coordinator

DEC 7 8 45 AM '83
RESEARCH DEVELOPMENT
DAVIS, CALIFORNIA

Enclosures

cc: Lab Contract and Grant Officers

*Note: The addressees above represent the standard distribution of Contracts and Grants Office Memos. Additional addressees, if any, may be added based on the subject of the Memo. See cc's.

TREASURY DEPARTMENT

WASHINGTON

OFFICE OF
COMMISSIONER OF INTERNAL REVENUE

ADDRESS REPLY TO
COMMISSIONER OF INTERNAL REVENUE
AND REFER TO

IT:P:T:1
CQ

SEP 14 1939

The Regents of the University of California,

Berkeley, California.

Attention: Luther A. Nichols,
Comptroller.

Sirs:

Reference is made to the information furnished by you for use in determining your status for Federal income tax purposes. The question of your exemption arose in connection with the Wilmerding School of Industrial Art, San Francisco, California.

The evidence discloses that you are the regularly constituted state university of the State of California created by a state legislative act in 1868; that you are engaged in educational activities; that your income is derived from investments, endowments, tuition, and miscellaneous sources; and that your income is used to defray general maintenance and operating expenses. The Wilmerding School of Industrial Art is under your control and is administered as a preparatory school and junior college.

It appears that you and your constituent schools are entitled to exemption under the provisions of section 101(6) of the Revenue Act of 1938 and the corresponding provisions of prior revenue acts. You are not, therefore, required to file returns for 1938 and prior years. Inasmuch as section 101(6) of Internal Revenue Code (53 Stat., Part 1) is similar to section 101(6) of the Revenue Act of 1938, returns of income will not be required for 1939 and subsequent years so long as there is no change in your organization, your purposes or your method of operation.

Any changes in your form of organization or method of operation, as shown by the evidence submitted, must be immediately reported to the collector of internal revenue for your district in order that the effect of such changes upon your present exempt status may be determined.

The exemption referred to in this letter does not apply to taxes levied under other titles or provisions of the Revenue Act of

The Regents of the University of California.

1938 and the corresponding provisions of prior revenue acts, or the Internal Revenue Code except insofar as exemption is granted expressly under those provisions to organizations enumerated in section 101(6) of the Revenue Act of 1938 and the corresponding provisions of prior revenue acts or in section 101 of the Internal Revenue Code.

Contributions made to you by individual donors are deductible by such individuals in arriving at their taxable net income in the manner and to the extent provided by section 23(o) of the Revenue Act of 1938 and the corresponding provisions of prior revenue acts, section 23(o) of Internal Revenue Code and section 23(o) of Internal Revenue Code as amended by section 224 of the Revenue Act of 1939. The deductibility of contributions by corporations is governed by section 23(q) of the Revenue Acts of 1936 and 1938, section 23(q) of Internal Revenue Code and section 23(q) of Internal Revenue Code as amended by section 224 of the Revenue Act of 1939.

A copy of this letter is being transmitted to the collector of internal revenue for your district.

By direction of the Commissioner.

Respectfully,

Deputy Commissioner.

Enclosure 3

Department of the Treasury

Internal Revenue Service

Date 28 NOV 1973

In reply refer to T:MS:EO:R:1:3

EIN DO 94

The Regents of the University
of California
Suite 689, University Hall
2200 University Avenue
Berkeley, California 94720

Gentlemen:

Based on the information you submitted, we have classified you as an organization that is not a private foundation as defined in section 509(a)(1) of the Internal Revenue Code.

Your classification is based on the assumption that your operations will be as stated in your notification. Any changes in your purposes, character, or method of operation must be reported to your District Director, San Francisco, which is your key district for exempt organization matters.

We are notifying your key District Director of this action.

Sincerely yours,

Milton Cerny

Milton Cerny
Chief, Rulings Section I
Exempt Organizations Branch

State of California – The Resources Agency ARNOLD SCHWARZENEGGER, Governor
DEPARTMENT OF FISH AND GAME
http://www.dfg.ca.gov
Central Valley Bay-Delta Branch
4001 North Wilson Way
Stockton, California 95205-2486
(209) 948-7800

November 18, 2004

Dr. Johnnie Moore
CALFED Bay-Delta Authority
650 Capitol Mall, Fifth Floor
Sacramento, California 95814

Delta Smelt Research Proposal by Dr. William Bennett and Dr. Wim Kimmerer

Dear Dr. Moore:

I am writing to express my support for the accompanying proposal by Dr. Bennett and Dr. Kimmerer. The proposed investigation will build on promising earlier work to link vital delta smelt condition factors and rates to sub-regions of fish origin. I believe the proposed work will provide substantial guidance to California Bay-Delta Authority habitat restoration and species recovery efforts, and improve our understanding of the relative importance of factors influencing delta smelt survival and abundance levels. I am particularly interested in the potential of the proposed work to enhance our understanding of, and put into perspective, the impacts of the substantial annual direct loss of larval and juvenile delta smelt to water exports.

I also wish to express the intent of my program, which conducts the bulk of large-scale delta smelt monitoring in the estuary, to cooperate with Dr. Bennett, to the extent our resources allow, in the proposed collection and archiving of samples.

If you have any questions about our support for, or cooperation with, the proposed work, please contact me at (209) 948-7800.

Sincerely,

for

Patrick J. Coulston
Supervising Biologist

PC04K001.doc/cc

Tasks And Deliverables

Monitoring responses of the Delta Smelt population to multiple restoration actions in the San Francisco estuary

Task ID	Task Name	Start Month	End Month	Deliverables
1	Project Management	1	36	Semiannual and final reports. Periodic invoices
2	Fish sampling, growth and natal history (Bennett, Hobbs)	1	36	Measurement of otolith daily growth rates for individual fish and determination of natal habitat, population structure and migration trajectory through restoration sites in the SFE
3	Measures of fish condition using bioassays and histopathology biomarkers (Teh)	1	36	Assessment of contaminant effects on whole fish and tissue conditions in individual fish utilizing restored and natural habitats
4	Estimates of food availability and egg production (Kimmerer,Bennett)	1	36	Quantify the abundance of zooplankton prey and diet quantity and composition.

				Quantify the abundance of delta smelt eggs in restoration sites.
5	Integration and data analysis (Bennett et al.)	1	36	Integration of growth, natal habitat use and population structure, histological condition and egg production data into comprehensive model of popualtion dynamics.

Comments

If you have comments about budget justification that do not fit elsewhere, enter them here.

Budget Summary

Project Totals

Labor	Benefits	Travel	Supplies And Expendables	Services And Consultants	Equipment	Lands And Rights Of Way	Other Direct Costs	Direct Total	Indirect Costs	Total
$1,291,472	**$423,600**	**$47,400**	**$190,465**	**$0**	**$99,124**	**$0**	**$42,321**	**$2,094,382**	**$564,266**	**$2,658,648**

Do you have cost share partners already identified?
No.

If yes, list partners and amount contributed by each:

Do you have potential cost share partners?
No.

If yes, list partners and amount contributed by each:

Are you specifically seeking non−federal cost share funds through this solicitation?

Monitoring responses of the Delta Smelt population to multiple restoration actions in the San Francisco estuary

Monitoring responses of the Delta Smelt population to multiple restoration actions in the San Francisco estuary

Year 1 (Months 1 To 12)

Task	Labor	Benefits	Travel	Supplies And Expendables	Services And Consultants	Equipment	Lands And Rights Of Way	Other Direct Costs	Direct Total	Indirect Costs	Total

1: project management (12 months)	18202	5755	0	0	0	0	0	0	$23,957	5989	$29,946
2: Fish sampling, growth and natal history (Bennett, Hobbs) (12 months)	131525	40706	10000	35465	0	89124	0	8407	$315,227	54424	$369,651
3: Measures of fish condition using bioassays and histopathology biomarkers (Teh) (12 months)	190287	62808	1000	30000	0	0	0	0	$284,095	71024	$355,119
4: Estimates of food availability and egg production (Kimmerer,Bennett) (12 months)	59800	16986	3000	5000	0	0	0	5000	$89,786	49143	$138,929
5: Integration and data analysis (Bennett et al.) (12 months)	10238	2662	0	0	0	0	0	0	$12,900	3225	$16,125
Totals	**$410,052**	**$128,917**	**$14,000**	**$70,465**	**$0**	**$89,124**	**$0**	**$13,407**	**$725,965**	**$183,805**	**$909,770**

Year 2 (Months 13 To 24)

Task	Labor	Benefits	Travel	Supplies And Expendables	Services And Consultants	Equipment	Lands And Rights Of Way	Other Direct Costs	Direct Total	Indirect Costs	Total
1: project management (12 months)	19112	6043	0	0	0	0	0	0	$25,155	6289	$31,444

2: Fish sampling, growth and natal history (Bennett, Hobbs) (12 months)	**138140**	**48619**	**10000**	**25000**	**0**	**5000**	**0**	**8407**	$235,166	**55440**	$290,606
3: Measures of fish condition using bioassays and histopathology biomarkers (Teh) (12 months)	**199801**	**65948**	**1000**	**30000**	**0**	**0**	**0**	**0**	$296,749	**74187**	$370,936
4: Estimates of food availability and egg production (Kimmerer,Bennett) (12 months)	**62790**	**17835**	**4800**	**5000**	**0**	**0**	**0**	**5700**	$96,125	**45963**	$142,088
5: Integration and data analysis (Bennett et al.) (12 months)	**10763**	**2798**	**0**	**0**	**0**	**0**	**0**	**0**	$13,561	**3390**	$16,951
Totals	**$430,606**	**$141,243**	**$15,800**	**$60,000**	**$0**	**$5,000**	**$0**	**$14,107**	**$666,756**	**$185,269**	**$852,025**

Year 3 (Months 25 To 36)

Task	Labor	Benefits	Travel	Supplies And Expendables	Services And Consultants	Equipment	Lands And Rights Of Way	Other Direct Costs	Direct Total	Indirect Costs	Total
1: project management (12 months)	**20068**	**6345**	**0**	**0**	**0**	**0**	**0**	**0**	$26,413	**6603**	$33,016
2: Fish sampling, growth and natal	**145047**	**51050**	**10000**	**25000**	**0**	**5000**	**0**	**8407**	$244,504	**57774**	$302,278

history (Bennett, Hobbs) (12 months)												
3: Measures of fish condition using bioassays and histopathology biomarkers (Teh) (12 months)	209791	74400	1000	30000	0	0	0	0	$315,191	78798	$393,989
4: Estimates of food availability and egg production (Kimmerer,Bennett) (12 months)	64607	18707	6600	5000	0	0	0	6400	$101,314	48457	$149,771
5: Integration and data analysis (Bennett et al.) (12 months)	11301	2938	0	0	0	0	0	0	$14,239	3560	$17,799
Totals	**$450,814**	**$153,440**	**$17,600**	**$60,000**	**$0**	**$5,000**	**$0**	**$14,807**	**$701,661**	**$195,192**	**$896,853**

Budget Justification

Monitoring responses of the Delta Smelt population to multiple restoration actions in the San Francisco estuary

Labor

Direct Labor Hours. Provide estimate hours proposed for each individual

(Task 1) Diana Cummings (Analysist) 416, Assistant 250. (Task 2) Dr. William Bennett 1040, Hobbs 2080, Jr. Specialist 2080, GSR I 2080 (Task 3) Dr. Swee Teh RB IV 520, Post-Doc I 2080, Histopathologist 2080, Lab Assis 2080, Undergrad 520 (Task 4) Dr. Wim Kimmerer 416, Research Assistant II 1040, Student Assistant I 1040, (Task 5) Dr. William Bennett, 520 Salary. Provide estimated rate of compensation proposed for each individual. (Task 1) Diana Cummings (Analysist) $35.72/Hr, Assistant $42.56/Hr. (Task 2) Dr. William Bennett $33.06/HR, Dr. Hobbs Post-Doc $29.26/HR, Jr. Specialist $17.91/HR GSR I $21.10/HR (Task 3) Dr. Swee Teh RBIV $52.78/HR, Post-Doc I $29.26/HR, Histopathologist $61.30/HR, Lab Assis. $27.73, Undergrad $9.90/HR (Task 4) Dr. Wim Kimmerer $55.50/HR, Research Assistant II $27.04/HR, Student Assistant I $24.60/HR, (Task 5) Dr. William Bennett $33.06/HR,

Benefits

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

(Task 1) Diana Cummings (Analysist) 26%, Assistant 26%. (Task 2)Dr. William Bennett RS III 26%/Yr, Dr. Hobbs Post-Doc 38%/Yr, Jr. Specialist 20%/Yr, GSRI 38% (Task 3) Dr. Swee The RB IV 28%/Yr Post-Doc I 38%/Yr, Histopathologist 35%/Yr, Lab Assis. 30%/Yr, undergrad 3% (Task 4) Dr. Wim Kimmerer 48%/\Yr, Research Assistant II 48%/Yr, Student Assistant I 1.5%/Yr, (Task 5) Dr. William Bennett RS III 26%/Yr

Travel

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

Travel money will be used for travel to and from field sites. (Task 1) no travel (Task 2) Bennett: $30,000. day trips to Skinner Fish Facility, 2 overnight trips per month from April-June, 1 overnight trip per month from June to March. Minimum of 2 people. Transportation to and from CALFED meetings, IEP meetings and research team meetings. Transportation to regional conferences (e.g. Assilomar, ERF.) Hobbs: Week long trips to the subregions of the watershed to collect water samples for trace element/isotope analysis.

(Task 3) Teh, $3,000. Transportation to and from CALFED meetings, IEP meetings and research team meetings. Transportation to regional conferences (e.g. Assilomar, ERF.

(Task 4) Kimmerer: $14,400. Transportation to and from CALFED meetings, IEP meetings and research team meetings. Transportation to regional conferences (e.g. Assilomar, ERF., and three national meetings. Boat use 10 days/Yr (Task 5) No travel

Supplies And Expendables

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

(Task 2.) Dr. William Bennett; Office $5,800 Laboratory $34,125 Computing, $9,500 Field $36,040

(Task 3.) Dr. Swee Teh; Office $9,000 Laboratory $60,300 Computing, $ 20,700 Field $0 • field tasks for Task 2 will be completed by the Bennett Lab.

(Task 4.) Dr. Wim Kimmerer; Office, $1,500, Laboratory, $10,050, Computing, $3,000, Boat use 10day/Yr, $17,100 (Task 5) None

Services And Consultants

None

Equipment

(TASK 2) Nikon Flourescent Microscope $84,124, Otolith Polishing Wheel $10,000 CCD Digital Camera $5000

Lands And Rights Of Way

NonE

Other Direct Costs

(Task 2) Fee Remission for PhD Student $25,221 (Task 4) Fee Remission for Masters student $14,100 (task 4) Boat time $3,000.

Indirect Costs/Overhead

****Modified Total Direct Costs (MTDC) consists of all salaries and wages, fringe benefits, materials, supplies, services, travel and subgrants and subcontracts up to the first $25,000 of each subgrant or subcontract (regardless of the period covered by the subgrant of subcontract). Modified total direct costs shall exclude equipment (hardware which exceeds the unit cost of $5000) capital expenditures, charges for patient care tuition remission, rental costs of off−site facilities, scholarships, and fellowships as well as the portion of each subgrant and subcontract in excess of $25,000. Modified Total Direct Costs (MTDC) consists of all salaries and wages, fringe benefits, materials, supplies, services, travel**

The applied overhead rate is based on "State Funds" = 25% of MTDC including up to the first $25,000 of subcontrated to SFSU.

SFSU overhead rate of 50% of MTDC not including the first

$25,000

Comments

Environmental Compliance

Monitoring responses of the Delta Smelt population to multiple restoration actions in the San Francisco estuary

CEQA Compliance

Which type of CEQA documentation do you anticipate?
X none
− negative declaration or mitigated negative declaration
− EIR
− categorical exemption

If you are using a categorical exemption, choose all of the applicable classes below.
− Class 1. Operation, repair, maintenance, permitting, leasing, licensing, or minor alteration of existing public or private structures, facilities, mechanical equipment, or topographical features, involving negligible or no expansion of use beyond that existing at the time of the lead agency's determination. The types of "existing facilities" itemized above are not intended to be all−inclusive of the types of projects which might fall within Class 1. The key consideration is whether the project involves negligible or no expansion of an existing use.
− Class 2. Replacement or reconstruction of existing structures and facilities where the new structure will be located on the same site as the structure replaced and will have substantially the same purpose and capacity as the structure replaced.
− Class 3. Construction and location of limited numbers of new, small facilities or structures; installation of small new equipment and facilities in small structures; and the conversion of existing small structures from one use to another where only minor modifications are made in the exterior of the structure. The numbers of structures described in this section are the maximum allowable on any legal parcel, except where the project may impact on an environmental resource of hazardous or critical concern where designated, precisely mapped, and officially adopted pursuant to law by federal, state, or local agencies.
− Class 4. Minor public or private alterations in the condition of land, water, and/or vegetation which do not involve removal of healthy, mature, scenic trees except for forestry or agricultural purposes, except where the project may impact on an environmental resource of hazardous or critical concern where designated, precisely mapped, and officially adopted pursuant to law by federal, state, or local agencies.
− Class 6. Basic data collection, research, experimental management, and resource evaluation activities which do not result in a serious or major disturbance to an environmental resource, except where the project may impact on an environmental resource of hazardous or critical concern where designated, precisely mapped, and officially adopted pursuant to law by federal, state, or local agencies. These may be strictly for information

gathering purposes, or as part of a study leading to an action which a public agency has not yet approved, adopted, or funded.

− Class 11. Construction, or placement of minor structures accessory to (appurtenant to) existing commercial, industrial, or institutional facilities, except where the project may impact on an environmental resource of hazardous or critical concern where designated, precisely mapped, and officially adopted pursuant to law by federal, state, or local agencies.

Identify the lead agency.

Is the CEQA environmental impact assessment complete?

If the CEQA environmental impact assessment process is complete, provide the following information about the resulting document.

Document Name

State Clearinghouse Number

If the CEQA environmental impact assessment process is not complete, describe the plan for completing draft and/or final CEQA documents.

NEPA Compliance

Which type of NEPA documentation do you anticipate?

X none

− environmental assessment/FONSI

− EIS

− categorical exclusion

Identify the lead agency or agencies.

If the NEPA environmental impact assessment process is complete, provide the name of the resulting document.

If the NEPA environmental impact assessment process is not complete, describe the plan for completing draft and/or final NEPA documents.

Successful applicants must tier their project's permitting from the CALFED Record of Decision and attachments providing programmatic guidance on complying with the state and federal endangered species acts, the Coastal Zone Management Act, and sections 404 and 401 of the Clean Water Act.

Please indicate what permits or other approvals may be required for the activities contained in your proposal and also which have already been obtained. Please check all that apply. If a permit is *not* required, leave both Required? and Obtained? check boxes blank.

Local Permits And Approvals	Required?	Obtained?	Permit Number (If Applicable)
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	Required?	Obtained?	Permit Number (If Applicable)
scientific Collecting Permit	X	X	
CESA Compliance: 2081	–	–	
CESA Complance: NCCP	–	–	
1602	–	–	
CWA 401 Certification	–	–	
Bay Conservation And Development Commission Permit	–	–	
reclamation Board Approval	–	–	
Delta Protection Commission Notification	–	–	
state Lands Commission Lease Or Permit	–	–	

action Specific Implementation Plan	–	–	
other	–	–	

Federal Permits And Approvals	Required?	Obtained?	Permit Number (If Applicable)
ESA Compliance Section 7 Consultation	–	–	
ESA Compliance Section 10 Permit	–	–	
Rivers And Harbors Act	–	–	
CWA 404	–	–	
other USFWS Permit To House Threatened Delta Smelt Specimens	X	–	

Permission To Access Property	Required?	Obtained?	Permit Number (If Applicable)
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	–	–	

If you have comments about any of these questions, enter them here.

We have applied for the permit.

Land Use

Monitoring responses of the Delta Smelt population to multiple restoration actions in the San Francisco estuary

Does the project involve land acquisition, either in fee or through easements, to secure sites for monitoring?
X No.
– Yes.

How many acres will be acquired by fee?

How many acres will be acquired by easement?

Describe the entity or organization that will manage the property and provide operations and maintenance services.

Is there an existing plan describing how the land and water will be managed?
– No.
– Yes.

Will the applicant require access across public or private property that the applicant does not own to accomplish the activities in the proposal?
X No.
– Yes.

Describe briefly the provisions made to secure this access.

Do the actions in the proposal involve physical changes in the current land use?
X No.
– Yes.

Describe the current zoning, including the zoning designation and the principal permitted uses permitted in the zone.

Describe the general plan land use element designation, including the purpose and uses allowed in the designation.

Describe relevant provisions in other general plan elements affecting the site, if any.

Is the land mapped as Prime Farmland, Farmland of Statewide Importance, Unique Farmland, or Farmland of Local Importance under the California Department of Conservation's Farmland Mapping and Monitoring Program?

X No.

– Yes.

Land Designation	Acres	Currently In Production?
Prime Farmland		–
Farmland Of Statewide Importance		–
Unique Farmland		–
Farmland Of Local Importance		–

Is the land affected by the project currently in an agricultural preserve established under the Williamson Act?

X No.

– Yes.

Is the land affected by the project currently under a Williamson Act contract?

X No.

– Yes.

Why is the land use proposed consistent with the contract's terms?

Describe any additional comments you have about the projects land use.