I1-045

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Ms. Kate Hansel
CALFED Bay-Delta Program
1416 Ninth Street, Suite 1155
Sacramento CA 95814

Dear Ms. Hansel:

Enclosed are 10 copies of an Inquiry Proposal entitled "Introduced Species: Potential Impediments to Restoration of the Bay-Delta Aquatic Ecosystem", in which my Co-Principal Investigators are Bill Bennett of the Bodega Marine Laboratory and Steve Bollens of the Romberg Tiburon Center. I am submitting this as an Inquiry rather than as a full proposal because it was not clear to me from the RFP or the other information I have received whether this research fits CALFED's perceived interests. I believe CALFED should be interested in this work, because the success of the CALFED process will be measured by how well the fish do, not by how big an effort is expended. If the fish do poorly in spite of the best efforts at restoration, it would be useful to know why and to have realistic expectations in advance.

I look forward to hearing from you after your evaluation, and I hope then to prepare a full proposal.

Sincerely,

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INQUIRY SUBMITTAL

Introduced Species: Potential Impediments to Restoration of the Bay-Delta Aquatic Ecosystem

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Project Description: Introduced species can alter an ecosystem in ways that inhibit restoration of the system to a previous state. The San Francisco Bay-Delta ecosystem has been invaded by a large number of species that have substantially altered lower trophic levels and may have affected some fish populations. *Our objective is to understand the effects of selected introductions, and how those effects may interfere with restoration efforts for three CALFED priority habitats: tidal perennial aquatic habitat, midchannel islands and shoals habitat, and Delta agricultural wetlands.*

The proposed research would focus on effects of the clam *Potamocorbula amurensis*, two species of copepod, and inland silversides. The effects of *P. amurensis* on the concentration of chlorophyll and the abundance of certain zooplankton species has been well-documented (Alpine and Cloern 1992, Kimmerer et al. 1994, Kimmerer and Orsi 1996). The energy supply for the aquatic ecosystem from phytoplankton and organic matter should limit the total biomass of higher trophic levels. The observed ~50% decrease in the available phytoplankton in late spring-summer in the northern estuary, starting in 1987, should have resulted in substantial and measurable declines in abundance of most species. Declines occurred in some species but not others, indicating a loose coupling in the food web between phytoplankton and fish. Our research will investigate why some fish species but not others appear to have declined relative to their previous abundance patterns. Since the disconnect in the response of the estuarine food web seems to have occurred either between phytoplankton/bacteria and zooplankton, or between zooplankton and fish, we propose to focus our research effort on those linkages.

The total abundance of zooplankton changed less than the abundance of individual species following the invasion of *P. amurensis*. Two species of copepod and one species of mysid filled the gap in abundance. The copepod *Pseudodiaptomus forbesi* became abundant in 1988, and in summer occupies a salinity range slightly upstream of that previously occupied by *Eurytemora affinis*. *Tortanus dextrilobatus*, a remarkably abundant predator on other zooplankton, occupies a salinity range somewhat seaward of that which *E. affinis* previously occupied. Both species of zooplankton are providing food for fish, but we do not understand why they are able to exist in this food-poor environment, the effect of predation by *T. dextrilobatus* on the rest of the food web, or how these exotics may interfere with restoration efforts.

Exotic inland silversides (*Menidia beryllina*) may be an important factor regulating the abundance of delta smelt during the low-outflow years since 1981. Silversides may be predators on larvae and may compete for resources with juvenile and adult delta smelt, particularly during dry years (Bennett 1995). We propose field studies to investigate the linkage between silversides and larval delta smelt, and between both species and zooplankton.

Approach: Our research plan calls for investigations of trophic linkages between

phytoplankton/bacteria and zooplankton, zooplankton and *Potamocorbula*, zooplankton and fish, and silversides and delta smelt. We will quantify these relationships using analyses of field-collected samples and laboratory experiments, and translate them into an ecosystem context using existing monitoring data. Field studies will be focused on examining the degree of spatial and temporal overlap among the various species of interest, which will be used to interpret the laboratory studies. In addition, we will analyze gut contents and otoliths of field-collected fish (silversides, delta smelt, and longfin smelt), and compare consumption with field estimates of zooplankton abundance to determine the degree of food limitation at different levels of zooplankton abundance. Mesocosm experiments will also be conducted to determine maximum growth rates under food-satiated conditions. Feeding and predation experiments will be used to determine the vulnerability of zooplankton species to predation and competition by *Potamocorbula* and interactions among zooplankton species.

Schedule: We anticipate starting in late spring of 1998. Field work will take place in spring-early summer of each year. In Year 1 we will also conduct experiments to examine consumption of zooplankton by *Potamocorbula* and investigate predation by *Tortanus*. In Year 2 we will examine food-limitation of these zooplankton and suitability of each as food for larval and juvenile fish. In Year 3 we will conduct experiments on predation and competition by silversides on delta smelt. This schedule calls for Bennett's participation to be greatest in Year 3, assuming that his proposal to CALFED to work on contaminant effects is successful.

Justification: The 1994 accord set standards for X_2 based on relationships between X_2 and fish abundance. Recent analyses (Kimmerer 1997) have shown that some of these relationships have weakened since the introduction of *Potamocorbula* and other species. Restoration of the aquatic ecosystem, either through the use of water or by other means, may be inhibited by the changes in the ecosystem caused by these introduced species. We suggest that it would be of paramount importance to CALFED to understand these new constraints on restoration, so the effectiveness of restoration activities is not held to an unrealistic standard. By examining limitation of the food web, this proposal addresses all CALFED priority fish species that occur in the estuary, with emphasis on delta and longfin smelt.

Budget estimate: Year 1: $200,000; Year 2: $220,000; Year 3: $250,000; no third-party impacts

Applicant Qualifications: ***Dr. Wim Kimmerer (PI)*** has 20 years of experience on the ecology of bays and estuaries, including 11 years in the Bay-Delta region, and works closely with IEP and other Bay area scientists on lower trophic levels, fish populations, data interpretation, and modeling. ***Dr. William A. Bennett (Co-PI)*** has ten years of research experience on the ecology of Bay/Delta fish populations, during which he has been a frequent collaborator with IEP member agencies. ***Dr. Stephen Bollens (Co-PI)***, who joined the Tiburon Center faculty in 1996, has an extensive record of successful research and publication on predatory interactions among zooplankton and larval fish at the University of Washington and Woods Hole Oceanographic Institution.

Coordination: The ideas for this research have been developed over the last several years through collaboration between two of the PI's (Kimmerer and Bennett) and other members of the IEP's Estuarine Ecology Team (EET). This project will become a significant part of the work program of that team, who will be asked to provide peer review at all stages of the project. We also anticipate that members of the EET will be invited to participate in this project; in particular we will invite James Orsi (Fish and Game) to participate, expanding the scope to include mysids.

ATTACHMENT: References Cited

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