



CALFed Progress Questionnaire
California Sea Grant College Program

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Project Information

ProjectNo\_2C R/SF-15 StartDate\_3a 01/01/07 EndDate\_3b 12/31/09
ProjectTitle\_4 Prey selection of larval and juvenile planktivorous fish in the San Francisco Estuary

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Additional Research Mentors and Community Mentors

Additional Research Mentors\_8

Form with 5 horizontal lines for entering additional research mentors.

Additional Community Mentors\_9

Form with 5 horizontal lines for entering additional community mentors.



**Project Objectives: Please type your responses, and answer the questions in a style appropriate for laymen.**

**ProjectObjectives\_10**

The abundance and species composition of zooplankton in the San Francisco Estuary have undergone several changes in the last two decades. These changes have been correlated to declines in the abundance of planktivorous fish, including delta smelt. The main objective of this project is to quantify prey selection of larval and juvenile planktivorous fish in the San Francisco Estuary. Because growth and survival of larval and juvenile fish depends on encounter with and consumption of appropriate prey items during development, information on prey selection and the mechanisms that control it will help determine how changes in the available prey translate into population success.

During this study, prey selection will be quantified with two different approaches: (1) laboratory feeding experiments and (2) video observations. First, prey selection will be measured in laboratory feeding experiments during which fish will be incubated with known concentrations of mixed copepods. Ingestion will be quantified using gut content analysis. Following the incubation experiments, predator-prey interactions between fish and copepods will be examined using video observations. Data regarding the individual components of predation (encounter rates, attack rates, capture efficiency and ingestion) will be used to help determine what controls prey selection.

**Summary of progress in meeting each of these goals and objectives**

**ProgressSummary\_11**

Laboratory feeding experiments: Incubation experiments to quantify prey selection were performed with larval and juvenile delta smelt (*Hypomesus transpacificus*) and striped bass (*Morone saxatilis*). In 2008, 18 additional incubation experiments were conducted (6 with delta smelt; 12 with striped bass). In total, 55 incubation experiments have been conducted (37 with delta smelt; 18 with striped bass). Prey selection was quantified for both larval (naupliar) and juvenile (copepodid) copepods. Various combinations of five different copepod species were used in experiments depending on their temporal and spatial overlap with the early life history stages of delta smelt and striped bass. Copepods included both native and non-native species (*Eurytemora affinis*, *Pseudodiaptomus forbesi*, *Limnoithona tetraspina*, *Acartiella sinensis*, *Acanthocyclops vernalis*). The samples resulting from these experiments are currently being processed. Sampling processing is anticipated to be completed by June 2009. Data analysis is ongoing. Publications are currently being prepared. No additional incubation experiments are planned.

**Preliminary results (Laboratory feeding experiments):**

Both larval and juvenile delta smelt and striped bass fed selectively on copepods. More specifically, they consumed copepodite stages in higher proportions than naupliar stages for all prey species examined (*Eurytemora affinis*, *Pseudodiaptomus forbesi*, *Limnoithona tetraspina*, *Acartiella sinensis*, *Acanthocyclops vernalis*). Additionally, larval delta smelt (15–30 dph) consumed *L. tetraspina* copepodites in higher proportions than *E. affinis* or *P. forbesi* nauplii. This is surprising because at these stages all three species are similar in size, suggestion that morphology or behavior of the prey is controlling selection. Larval delta smelt (15–30 dph) consumed *E. affinis*, *P. forbesi* and *L. tetraspina* copepodites in proportion to their abundance in the assemblage. Based on fish gape and copepod length measurements, the early copepodid stages of *E. affinis* and *P. forbesi* and the late copepodid stages of *L. tetraspina* are of optimal prey size for larval delta smelt (15 dph). Larval striped bass (15–30 dph) showed similar patterns. Data for later stage fish (60–120 dph) of both species are still being processed.

Video observations: Video observations of larval delta smelt (15 dph) feeding on three species of copepods were made (*Eurytemora affinis*, *Pseudodiaptomus forbesi*, *Limnoithona tetraspina*). The video was examined and data regarding the individual components of selection were recorded including attack rates and capture efficiency. Additional video observations to increase replication are planned for June 2009.

Preliminary results (Video observations): At similar prey concentration ( $\approx$  encounter rates), larval delta smelt (15 dph) had high attack rates on the copepodite stages of *E. affinis* and *P. forbesi*. Attack rates on the copepodite stages *L. tetraspina* were significantly lower. Conversely, larval delta smelt had significantly higher capture efficiency on *L. tetraspina* compared to *E. affinis* and *P. forbesi*. The contrasting pattern between attack rate and capture efficiency work to cancel each other out and result in the lack of selection.

**PROJECT MODIFICATIONS:** Please explain any substantial modifications in research plans, including new directions pursued. Describe major problems encountered, especially problems with experimental protocols and how they were resolved. Describe any ancillary research topics developed.

**Modifications\_12**

We originally proposed to examine prey selection of three species of planktivorous fish, longfin smelt (*Spirinchus thaleichthys*), delta smelt (*Hypomesus transpacificus*), and striped bass (*Morone saxatilis*). However, the abundance of longfin smelt in the San Francisco Estuary has greatly declined since the inception of the proposal and we were unable to obtain larvae for use in experiments. Consequently, more experiments were performed to examine prey selection of delta smelt and striped bass. Although delta smelt are also in low abundance in situ, they are successfully being cultured by the Fish Conservation and Culture Laboratory in Byron, CA. Similarly, striped bass larvae were obtained from cultures at the University of California, Davis.

We also proposed to examine the impact of different light and turbidity levels on prey selection. However, larval feeding of both delta smelt and striped bass was only stimulated under ideal environmental conditions. Therefore, the impacts of differing light and turbidity levels on prey selection could not directly be examined.

Finally, video observations of predator-prey interactions were originally planned for the larval stages of all three fish species. Extreme sensitivity of striped bass to stress prevented their use in these experiments.

**BENEFITS AND APPLICATIONS:** Suggest the relevance of these new findings to management. Describe any accomplishment, that is significant effects your project has had on resource management or user group behavior. CALFED is looking for "management cue" (see <http://science.calwater.ca.gov/pdf/soemgmtcues.pdf>).

**BenefitsApplic\_13**

Results demonstrate that larval delta smelt and striped bass (15–30 dph) consume the copepodite stages of *E. affinis*, *P. forbesi* and *L. tetraspina* in approximately the same proportion to their abundance in the prey assemblage. This contradicts prevailing views that *L. tetraspina* avoids predation by planktivorous fish because of its small size, and suggests that *L. tetraspina* may be an important prey item for newly hatched larval planktivorous fish. Although all three species of copepod are consumed in similar proportions, the relative contribution of these copepods to the diet of larval fish differs greatly because *L. tetraspina* has approximately 1/10th the carbon content of *E. affinis* or *P. forbesi*. However, this difference in carbon content may be offset by the high numerical abundance of *L. tetraspina*, which are often 10X as abundant as all other copepod species combined. We expect selection patterns of later stages (60–120 dph) to shift toward larger prey items. This would match data collected from gut content analysis of field-collected fish.

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**PUBLICATIONS:** List any publications, presentations, or posters that have resulted from this funded research. Give as many details as possible, including status of paper (e.g., in review; in press), journal name, conference location and date of presentation. Please note (as outlined in the conditions of the award) that each fellow is required to submit an abstract for an oral or poster presentation at each State of the Estuary conference and CALFED Science Conference during the duration of the fellowship.

**Publications 14**

Sullivan, L.J. 2009. "As goes the smelt, so goes the delta: Feeding and growth of larval delta smelt in the San Francisco Estuary." Seminar, Dominican University of California, San Rafael, California, January, 29.

Sullivan, L.J. 2008. "Prey selection of larval fish in the San Francisco Estuary: Baked potato or French fry?" Seminar, Whittier College, Whittier, California, November, 17.

Sullivan, L.J., W.J. Kimmerer, B. Baskerville-Bridges and T.R. Ignoffo. 2008. "Prey selection of larval delta smelt and striped bass: Impacts of an introduced species." Oral presentation, 5th Biennial CALFED Science Conference, Sacramento, California, October, 23.

Sullivan, L.J., W.J. Kimmerer, B. Baskerville-Bridges and T.R. Ignoffo. 2008. "Prey selection of larval planktivorous fish in the San Francisco Estuary: Impacts of an introduced species." Oral presentation, 8th Larval Biology Symposium, Lisboa, Portugal, July, 9.

Sullivan, L.J. 2008. "Ocean Invaders: Potential Impacts on Pelagic Food Webs." Seminar, East Carolina University, Greenville, North Carolina, April, 17.

Sullivan, L.J., W.J. Kimmerer and B. Baskerville-Bridges. 2008. "Prey selection of larval delta smelt: Baked Potato or French fry." Oral presentation, Interagency Ecological Program Annual Workshop, Pacific Grove, California, February, 28.

Sullivan, L.J., W.J. Kimmerer, T.R. Ignoffo and B. Baskerville-Bridges. 2007. "Prey selection of larval and juvenile planktivorous fish in the San Francisco Estuary." Poster presentation, State of the San Francisco Estuary Conference, Oakland, California, October, 16-18.

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