CALFED Progress Report
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ProjectYear_2A 3rd **ProjectNo_2C** R/SF-15

TypeQuestionnaire_2B Completion Questionnaire

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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

Additional Community Mentors_9

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

ProjectObjectives_10

Populations of planktivorous fish in the San Francisco Estuary (SFE) are in a state of decline. Declines in some species have been correlated to changes in the abundance and distribution of their zooplankton prey. Over the past two decades, there has been a shift in the species composition of zooplankton from a community dominated by calanoid copepods to one dominated by a single introduced cyclopoid copepod, Limnoithona tetraspina. Since its introduction, L. tetraspina has become the most abundant copepod in the brackish regions of the SFE, at times outnumbering all other species by a factor of ten. Because L. tetraspina is smaller than the historically dominant calanoid species, Eurytemora affinis and Pseudodiaptomus forbesi, the relative contribution of these groups to the total zooplankton biomass differs greatly. To examine how changes in the prey assemblage translate into population success of planktivorous fish in the SFE, we quantified the relative consumption of the different copepod groups by larval delta smelt (Hypomesus transpacificus) and striped bass (Morone saxatilis) using laboratory feeding experiments.

Summary of progress in meeting each of these goals and objectives

ProgressSummary_11

During this study, prey selection (relative consumption) was quantified using two different approaches: (1) laboratory feeding experiments and (2) video observations.

First, prey selection was measured in laboratory feeding experiments during which fish were incubated with known concentrations of mixed copepod species (50:50). Incubation experiments were performed with larval and juvenile delta smelt and striped bass. A total of 55 incubation experiments were 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 the different fish species. Copepods included both native and non-native species (Eurytemora affinis, Pseudodiaptomus forbesi, Limnoithona tetraspina, Acartiella sinesis, Acanthocyclops vernalis). Sampling processing is complete. Data analysis is ongoing. Publications are in prep and submission is anticipated for February 2010.

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 sinesis, 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 controls 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 (15–30 dph). Larval striped bass (15–30 dph) showed similar patterns. However, later stage fish (60–120 dph) of both species selected for the larger calanoid copepod species (E. affinis, P. forbesi) and against L. tetraspina.

Following the incubation experiments, predator-prey interactions between fish and copepods were examined using video observations. Data regarding the individual components of predation (encounter rates, attack rates, capture efficiency and ingestion) were used to investigate the patterns of prey selection observed in the incubation experiments.

Video observations of larval delta smelt (15 dph) feeding on three species of copepods were made (Eurytemora affinis, Pseudodiaptomus forbesi, Limnoithona tetraspina). At similar prey concentration (=encounter rates), larval delta smelt had high attack rates on the copepodite stages of the calanoid copepods (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 observed between these groups in the incubation experiments with early larvae.

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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, delta smelt (Hypomesus transpacificus), striped bass (Morone saxatilis) and longfin smelt (Spirinchus thaleichthys). However, the abundance of longfin smelt in the SFE 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 had also proposed to examine the impact of different light and turbidity levels on prey selection. However, feeding of larval 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 be examined directly.

Finally, video observations of predator-prey interactions were originally planned for the larval stages of all 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 larval planktivorous fish in the SFE. However, prey selection of later stage fish (60–120 dph) shifts towards the larger calanoid species indicating that this may only be true for newly hatched larvae.

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., and W.J. Kimmerer. 2009. "Feeding, growth and survival of larval planktivorous fish in the San Francisco Estuary: impacts of introduced prey." Oral presentation, Coastal and Estuarine Research Federation 20th Biennial Conference, Portland, Oregon, November, 3.

Sullivan, L.J., B. Colteaux, W.J. Kimmerer, and J. Lindberg. 2009. "Growth and survival of delta smelt fed field-collected copepods." Poster presentation, 9th Biennial State of the San Francisco Estuary Conference, Oakland, California, September, 29–30.

Sullivan, L.J. 2009. "Preliminary growth rates of delta smelt feeding on field-collected zooplankton." Oral presentation, Interagency Ecological Program Monitoring and Food Web Workshop, Sacramento, California, June, 25.

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.

COOPERATING ORGANIZATIONS: List those agencies and/or persons who provided financial, technical or

other assistance to your project since inception. Describe the nature of their collaboration.

CoopOrganiz_15

Equipment, space and delta smelt were obtained from the Fish Conservation and Culture Laboratory (FCCL). The FCCL is part of the Department of Biological and Agricultural Engineering at the University of California, Davis. Additionally, Bradd Baskerville-Bridges and Joan Lindberg of the FCCL provided guidance on experimental design, data analysis and presentation. Equipment, space and striped bass were obtained from David Ostrach at the Pathobiology, Conservation & Population Biology Laboratory, Department of Civil and Environmental Engineering, UC, Davis. David Ostrach also provided guidance on experimental design, data analysis and presentation.

AWARDS: List any special awards or honors that you, or mentor or members of the research team, have received during the duration of this project.

Awards_16

None.

KEYWORDS: List keywords that will be useful in indexing your project.

Keywords_17

striped bass, Morone saxatilis, delta smelt, Hypomesus transpacificus, larvae, selection, preference, introduced species, copepod, copepodite, nauplii, Limnoithona tetraspina, Eurytemora affinis, Pseudodiaptomus forbesi

PATENTS: List any patents associated with your project.

Patents_18

None.

Additions: Additional information can be added here. Please begin the text with the

number of the question you are adding to.

Additions_19