Feeding Habits of Longfin Smelt in the Upper San Francisco Estuary

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Longfin smelt (*Spirinchus thaleichthys*)

Introduction

In recent years, abundance of longfin smelt (*Spirinchus thaleichthys*) in the estuary has declined to record low levels, which prompted its candidacy for listing under the California Endangered Species Act. This decrease in abundance has coincided with the long term decline of other pelagic organisms, including calanoid copepods and mysids, some of which are important food items for young pelagic fishes. There is little information regarding longfin smelt use of available prey in the estuary. This study was conducted to investigate the temporal and spatial diet composition of age-0 longfin smelt as part of the Interagency Ecological Program's (IEP) Pelagic Organism Decline (POD) special studies.

Methods

Age-0 longfin smelt examined for gut contents were collected in 2005 and 2006 by several California Department of Fish and Game (DFG) surveys from San Pablo Bay upstream through the Delta (Figure 1).

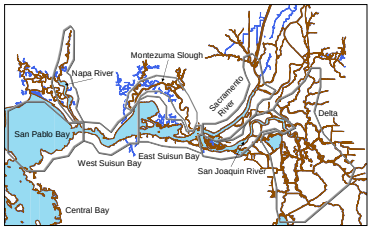

Figure 1. Regions sampled in the upper San Francisco Estuary.

Fish collected were preserved in 10% buffered formalin and brought to the laboratory (Stockton, CA) for examination. Fish were measured for fork length (mm), weighed (g), and gut contents were identified to the lowest taxon level possible and counted. Counts of copepods were multiplied by mean wet weight values and lengths of larger prey items (mysids, amphipods, etc.) were used to generate weights from length-weight equations. Prey types were grouped into 9 categories: other calanoid copepods, *Eurytemora affinis*, *Pseudodiaptomus* spp., other cyclopoid copepods, *Limnoithona* spp., mysids, *Gammarus* spp., *Corophium* spp., and other zooplankton. Feeding incidence was determined as the percentage of fish with gut contents present. Only fish with gut contents present were used in the following analyses.

Individual fish were pooled by month and region of collection and percent wet weight of the various categories was determined. Diet data was entered into PRIMER (v6) and square-root transformed, to create a Bray-Curtis similarity matrix (Clarke and Gorley 2006). The matrix was used in non-metric multidimensional scaling (MDS) ordination to examine the similarity in feeding of longfin smelt temporally and spatially. The percentage of each prey category was then displayed in the MDS plot as circles proportional to the percentage of wet weight. Grouping of samples was conducted with superimposed clusters around points on the MDS plot at arbitrary increasing levels of similarity at 20%, 40%, 60%, and 80%. One-way Analysis of Similarities (ANOSIM) were performed on the similarity matrix to determine if diet differed among months, years, or regions.

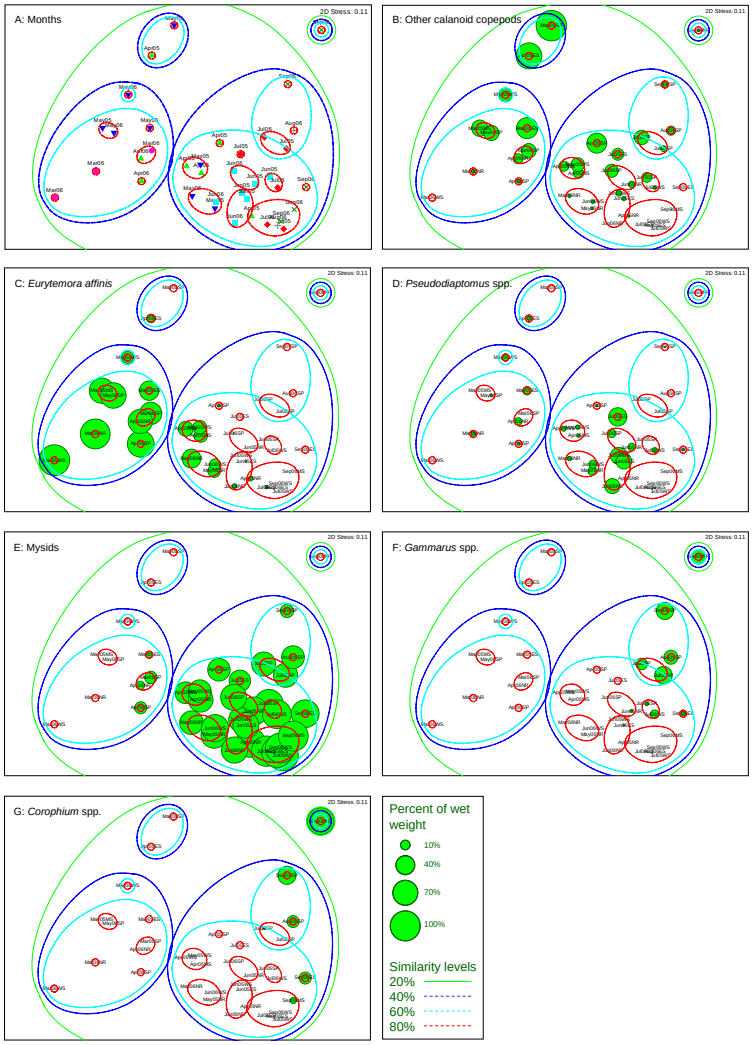

Figure 2. Non-metric multidimensional scaling (MDS) plot of the percentage wet weight diet data of longfin smelt collected in 2005 and 2006 by month and region (A; labeled only by month for ease of viewing). Monthly MDS plot repeated to include diameter of circles proportional to the percentage of wet weight of individual prey categories (B-G) in each month and region. Plots including prey categories "Other cyclopoid copepods", "*Limnoithona* spp." and "Other zooplankton" were not included as they contributed only 2.5%, 0.6% and 1.6% of the total wet weight, respectively. Regions identified as: SP = San Pablo Bay, NR = Napa River, WS = West Suisun Bay, ES = East Suisun Bay, and MS = Montezuma Slough.

Results

A total of 691 fish were processed for diet and of those 529 (77%) had gut contents present. The percentage of fish with gut contents present was high in May and June followed by a decline in July both years, with July 2006 having the lowest feeding incidence. Regional feeding incidence was highest in Montezuma Slough and lowest in West Suisun Bay.

The MDS ordination of monthly regional prey category weights, when labeled for months, revealed a gradation of points over time from left to right, with an increased point spread for more diverse diets (Figure 2A). The same plot labeled for years and regions did not reveal any trends.

The one-way ANOSIM confirmed the influence of months, as overall diet composition was significantly different among months (P = 0.001, Global R = 0.385), but not years (P = 0.338, Global R = 0.008) or regions (P = 0.323, Global R = 0.021).

The points on the MDS plot for the earliest time period, March, were on the left-hand side blending to the right into April and May (Figure 2A). April and May had a greater spread than March and June. June diets were the most similar with points concentrated near the lower center of the plot. The points for July increased in spread from June with a continued expansion in August and September.

Clusters revealed nearly all samples were within 20% of similarity, yet at 40% many of the samples in spring 2006 were different from spring 2005 and summer months of both years (Figure 2A).

Eurytemora affinis, other calanoid copepods, and mysids were the primary food items found in the guts of longfin smelt (Figures 2B-G) and these categories made up more than 83% of the total diet by weight. *Pseudodiaptomus* spp. and the amphipods *Gammarus* spp. and *Corophium* spp. were also somewhat important (Figures 2D, 2F-G). The remaining prey categories combined (other cyclopoid copepods, *Limnoithona* spp. and other zooplankton) contributed less than 5% to the total diet by weight.

The calanoid copepod *Eurytemora affinis* was important to age-0 longfin smelt in the spring (Figure 2C). Other regionally abundant calanoid copepods (*Tortanus* sp., *Sinocalanus doerrii*, and *Acartia* spp.), and *Pseudodiaptomus forbesi* were also utilized as food during spring and into July (Figures 2B, 2D). In summer and early fall, larger longfin smelt shifted to primarily eating mysids and amphipods (Figures 2E-G). Regionally as early as April and generally by June of both years, diet was dominated by mysids. In July and August, amphipods became regionally important.

Conclusions

- Longfin smelt relied heavily upon *Eurytemora affinis* as a spring food with other calanoid copepods being regionally important.
- Longfin smelt as they grew fed on larger organisms and mysids dominated the gut contents by the summer months.
- Amphipods were consumed later in the year, evidence of longfin smelt switching to large demersal prey items, possible due to low mysid numbers or mass.
- The temporal shift in diet followed changes in available prey and increasing size of longfin smelt.

Acknowledgements

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References

Clarke, K.R., and R.N. Gorley. 2006. PRIMER v6: User Manual/Tutorial. PRIMER-E Ltd., Plymouth, United Kingdom.