Abundance, composition, feeding, and reproductive rates of key copepod species in the food-limited Low Salinity Zone of the San Francisco Estuary

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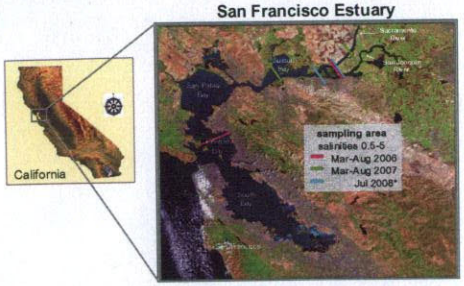
Project Objectives

Recent declines in the abundance of several pelagic fish species in the northern San Francisco Estuary (SFE) have prompted further investigation into the food web of the low salinity zone (LSZ). The LSZ is a region of low primary productivity and many introduced copepod species. We measured copepod abundance, species composition, and reproductive rates in an effort to understand the food web function in this region and its potential role in the fish decline. This was part of a larger project organized around a series of samples from March-August of 2006 and 2007 and August 2008, at fixed salinities of 0.5, 2, and 5.

San Francisco Estuary



* only salinity 2 sampling area shown for 2008. Fixed stations were occupied during 2008 transect study up the Sacramento River (salinities ranged from 0.1 to 13).

Methods

Chlorophyll

Surface water was filtered onto GF/F and 5 µm filters, for size-fractionated chlorophyll values in whole water and >5 µm cells, respectively. Pigments were extracted in 90% acetone and read on a Turner 10 fluorometer.

Copepod Abundance & Composition

Copepods were collected by vertical tow of a 0.5 m diameter, 53 µm mesh ring net, preserved in formalin and identified and counted by dissection microscopy.

Copepod Egg Production

Adult female *Acartiella sinensis* were collected from salinity 2 and incubated for 24 h in 125 mL bottles containing ambient water. We applied the egg ratio method[2] for *Eurytemora affinis*, *Pseudodiaptomus forbesi*, and *Limnoithona tetraspina*.

Acartiella Feeding Experiments

Copepods were collected at salinity 2 and female *A. sinensis* sorted into 1 L polycarbonate bottles containing 35 µm-filtered ambient baywater and prey (*L. tetraspina*). Treatment and control (prey only) bottles were prepared, with one *A. sinensis* added to bottles containing *Limnoithona* nauplii prey. Bottles were incubated for 24 h and remaining predators and prey were preserved and counted.

Acartiella sinensis adult female

Pseudiaptomus forbesi adult female

Eurytemora affinis gravid adult female

Limnoithona tetraspina nauplius (left), adult (right)

Acknowledgments

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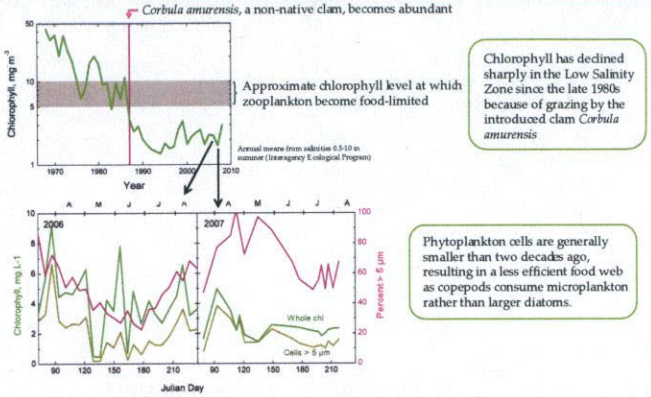
CALFED BAY-DELTA PROGRAM

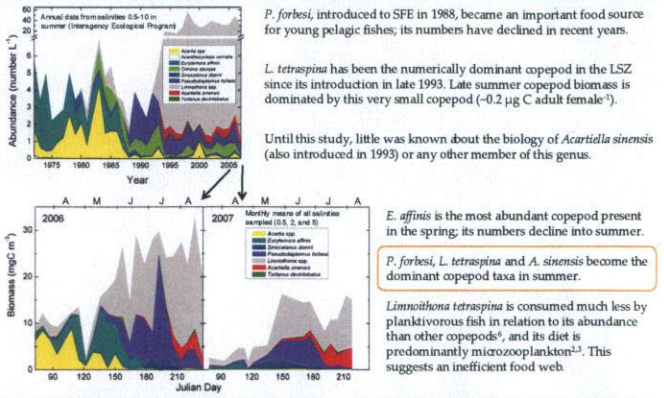
Chlorophyll



Chlorophyll has declined sharply in the Low Salinity Zone since the late 1980s because of grazing by the introduced clam *Corbula amurensis*

Phytoplankton cells are generally smaller than two decades ago, resulting in a less efficient food web as copepods consume microplankton rather than larger diatoms.

Adult Copepod Abundance & Biomass



P. forbesi, introduced to SFE in 1988, became an important food source for young pelagic fishes; its numbers have declined in recent years.

L. tetraspina has been the numerically dominant copepod in the LSZ since its introduction in late 1993. Late summer copepod biomass is dominated by this very small copepod (~0.2 µg C adult female^{-1}).

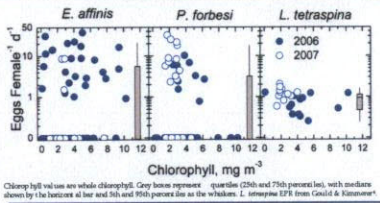
Until this study, little was known about the biology of *Acartiella sinensis* (also introduced in 1993) or any other member of this genus.

E. affinis is the most abundant copepod present in the spring; its numbers decline into summer.

P. forbesi, *L. tetraspina* and *A. sinensis* become the dominant copepod taxa in summer.

Limnoithona tetraspina is consumed much less by planktivorous fish in relation to its abundance than other copepods[6], and its diet is predominantly microzooplankton[2,3]. This suggests an inefficient food web.

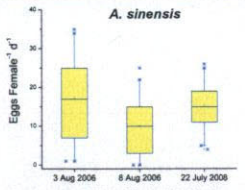
Copepod Egg Production



Chlorophyll values are whole chlorophyll. Grey boxes represent quartiles (25th and 75th percentiles), with medians shown by the horizontal bar and 5th and 95th percentiles as the whiskers. *L. tetraspina* EPR from Gould & Kimmerer[4].

Chlorophyll is not a good predictor of egg production rate (EPR) for any of the species in this study.

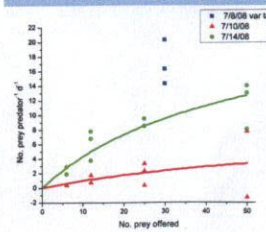
Smaller cells in 2006 than 2007 may have resulted in relatively lower mean EPR in copepods that are predominantly herbivorous (e.g., *Eurytemora*) whereas omnivorous copepods (*Pseudodiaptomus*, *Limnoithona*) had somewhat higher mean EPR when smaller phytoplankton cells were dominant.



Boxes represent quartiles (25th and 75th percentiles), with medians shown by the horizontal bar and 5th and 95th percentiles as the whiskers. Asterisks are outliers.

Acartiella sinensis, a predatory copepod and broadcast spawner, had a moderately high egg production rate, compared to *P. forbesi* and *E. affinis*, two relatively abundant, sac-carrying copepods in the LSZ.

Acartiella Predation on *Limnoithona* Nauplii



Acartiella and *Limnoithona* are concurrently abundant in late summer, so we performed preliminary feeding experiments to determine if *Acartiella* consumes *Limnoithona* nauplii.

Acartiella consumed *Limnoithona* nauplii at a clearance rate of ~17 ml h^{-1}, or a **potential predation impact of 1.3%** (i.e., % prey population consumed per day), comparable to *Tortanus dextrilobatus*[5] predation on *Oithona davisae* (on a per weight basis).

Observed densities of *L. tetraspina* would have been adequate to support a mean EPR of ~10 eggs *Acartiella* female^{-1} d^{-1}; our observed EPR values are consistent with this estimate.

Estimate based on the following assumptions: *L. tetraspina* nauplii body carbon[1] of 0.025 µg C; *A. sinensis* egg mass of 0.03 µg C; measured *A. sinensis* female body carbon of 3.6 µg C (data not shown); and *A. sinensis* gross growth efficiency of 40%.

Summary & Implications

- Chlorophyll declined sharply in the LSZ in the late 1980s and phytoplankton cells are smaller than two decades ago, resulting in a less efficient food web as copepods consume microzooplankton rather than larger diatoms.
- The copepod assemblage in the LSZ has shifted from one dominated by *Eurytemora affinis* (possibly introduced over a century ago) to one dominated by introduced species in summer, notably the very small cyclopoid *Limnoithona tetraspina*.
- The dominant copepod species in the LSZ have generally low reproductive rates compared to taxa in other areas of the SFE (e.g., up to 30 eggs female^{-1} d^{-1} for *Acartia* sp.), suggesting food limitation, as is also suggested by low growth rates (Ignoffo et al. poster, this session).
- The combination of low primary production, and a long and inefficient food web have likely contributed to declines of pelagic fish.

References

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