Long-Term Seasonal Trends in the Delta Smelt (*Hypomesus transpacificus*) Prey Community of the Sacramento-San Joaquin Delta, California

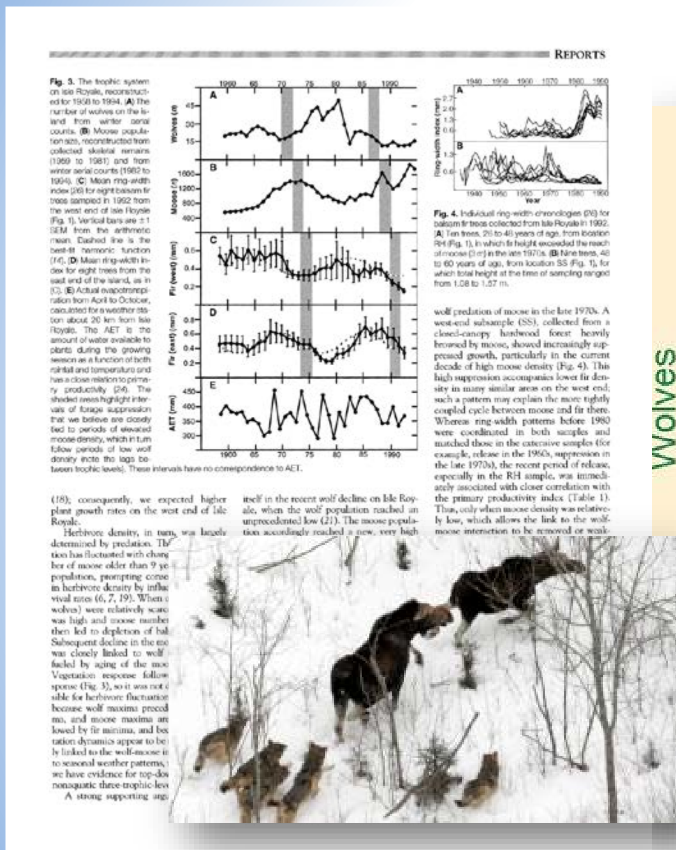
Joseph E. Merz
Paul S. Bergman
Josie Simonis
David Delaney
James Pierson
Paul Anders

CRAMER FISH SCIENCES®
Oregon • California • Washington • Idaho • Alaska

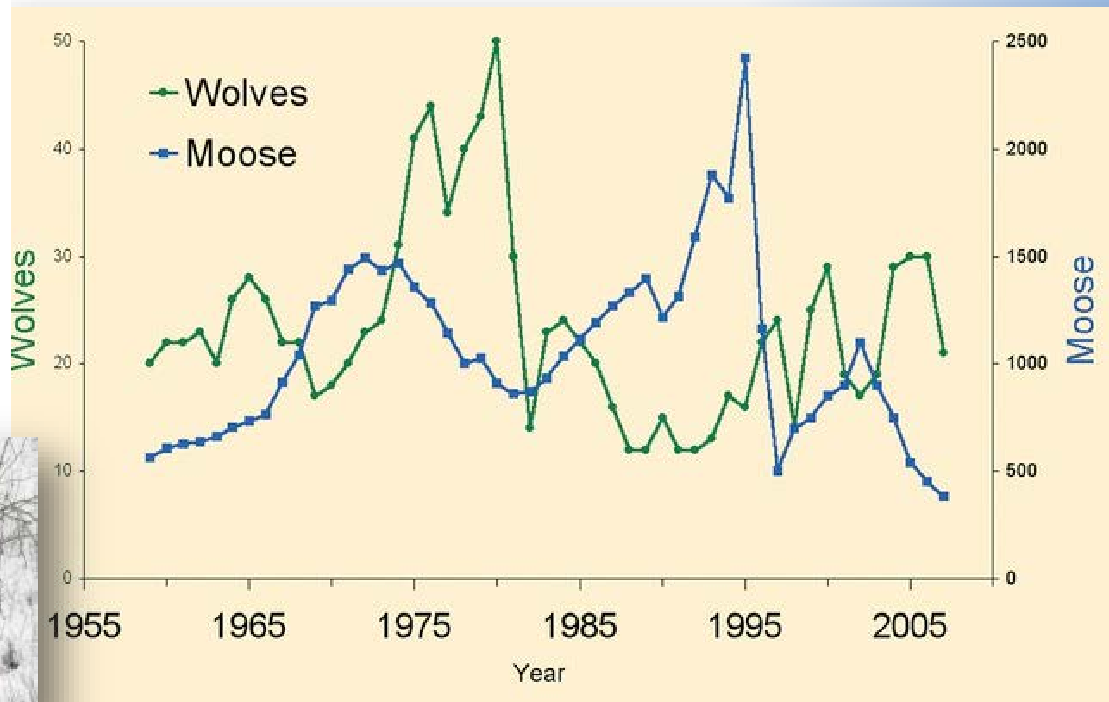
UNIVERSITY OF CALIFORNIA SANTA CRUZ

Innovation for a better future
University of Maryland CENTER FOR ENVIRONMENTAL SCIENCE

Persistence of food webs



Mech, L.D., 1966. wolves of Isle Royale.

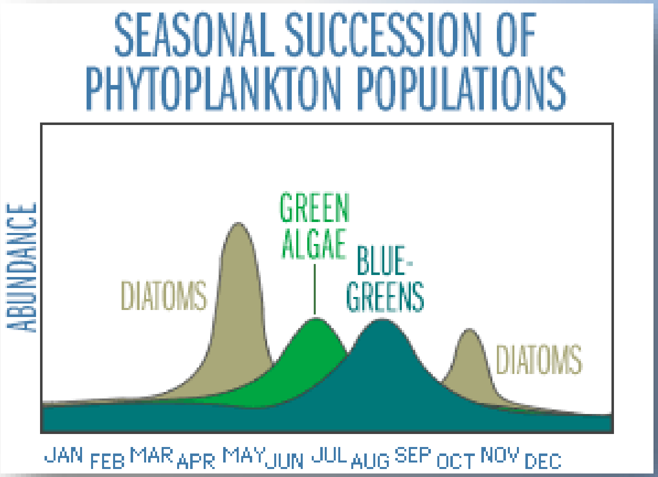


Food webs persist because stabilizing mechanisms, including synchronicity, play out within a hierarchy of biotic and abiotic processes; operating at local and regional scales (DeAngelis and Waterhouse 1987; Polis et al. 2004; McCann et al. 2005; Rooney et al. 2006; Gouhier et al. 2010).

Estuary food web

Intra-annual taxonomic succession at the zooplankton population and community levels is typically observed in freshwater systems; appears to be driven by seasonality in:

- light
- temperature, and
- nutrients (Sommer et al. 2012).



Courtesy of "Water on the Web"

Factors that influence these processes:

- Solar insolation
- precipitation
- water column light penetration and
- heat absorbance (Cloern 1991; Torremorell et al. 2009).

Problem

SF Estuary is highly invaded and shifts in abiotic conditions (e.g., flow, nutrients, clarity) have occurred...

Abiotic factors and species introductions can:

- alter food web timing
- disrupt life cycles
- change life history expressions and
- temporal scale of zooplankton population dynamics (Winder and Schindler 2004; Winder et al. 2009).
- Ultimately decouple food webs (Power 1992)

Undaria pinnatifida

NASA imagery

Study Goal

To examine temporal changes in the zooplankton community, and potential effects of these changes on the Estuary's food web, we investigated seasonal trends in:

- water quality,
- primary production, and
- key mesozooplankton taxa (defined as most common prey of federally listed, endemic fish species- delta smelt)

by analyzing a 43-year Estuary time-series dataset (1972–2014).

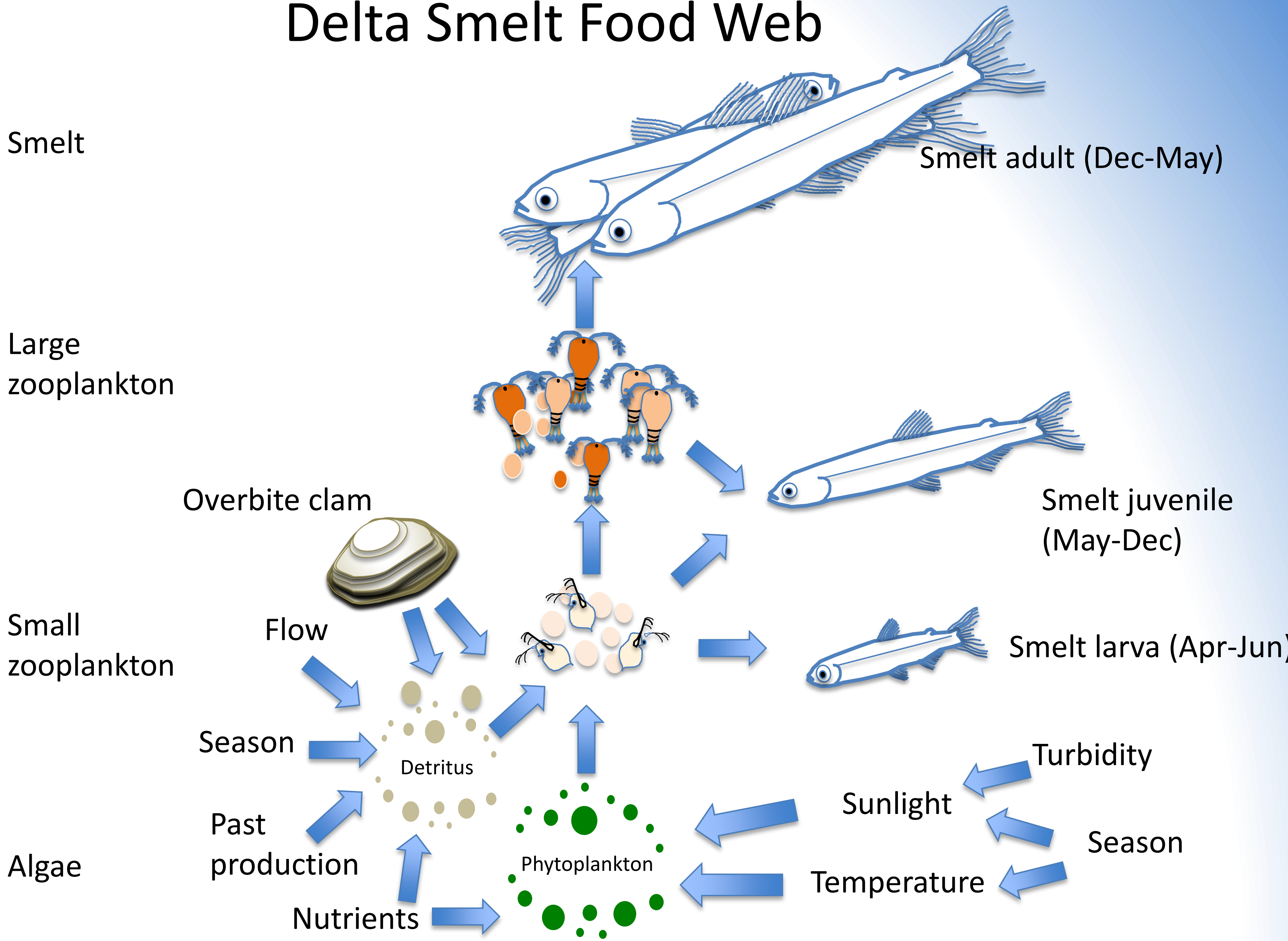
Objective:

Describe historic food web timing

Determine extent of temporal shifting of:

- water quality variables,
- primary productivity, and
- Estuary food web components, particularly zooplankton community

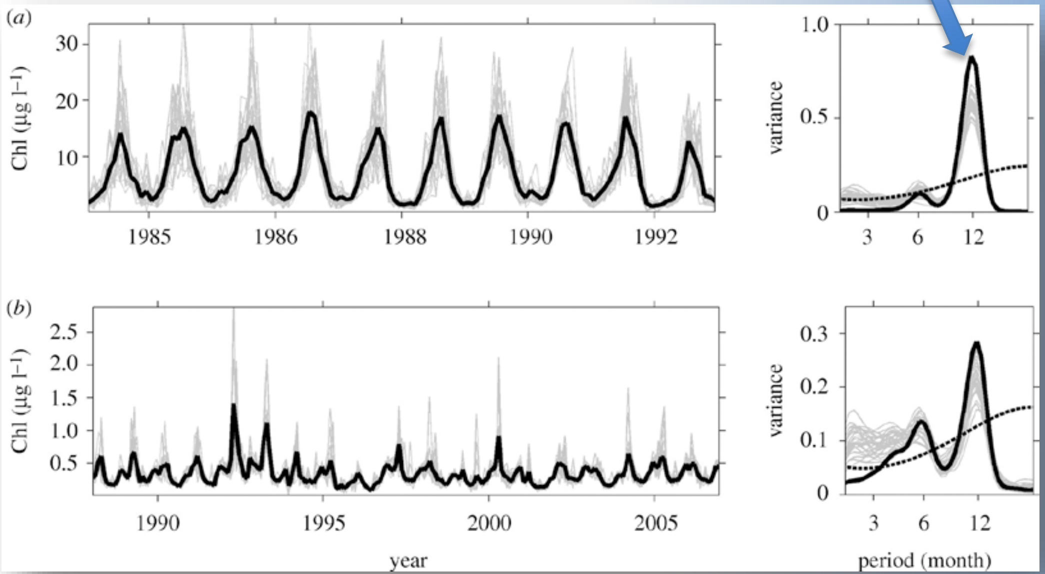
Delta Smelt Food Web



Hypothesis

Shift in peak day

During past 43-year period of sampling, rapid expansion of a suspension-feeding overbite clam (*Potamocorbula amurensis*), and synchronous declines in several pelagic organisms of the Estuary, including delta smelt, would coincide with altered food web timing.



Comparison of monthly time series and periodicity of Chl-a based on daily data (thick black line) and simulated monthly sampling (thin grey lines).

suspension-feeding bivalve

Long-term data

We examined physical, trophic, and zooplankton community dynamics in the San Francisco Estuary, California, a highly altered Mediterranean climate waterway, across a 43-year dataset (1972–2014).

Three periods:

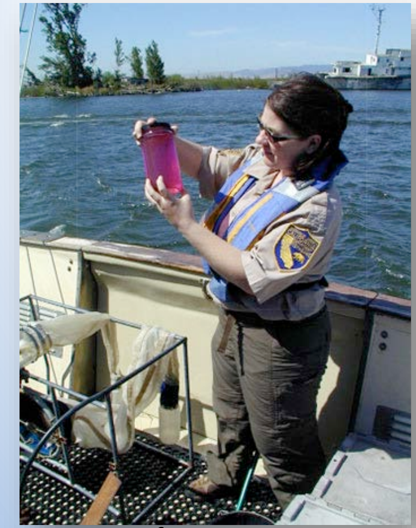
Before invading clam (1978-85)

After clam but before POD (1986-2001)

After POD (2002-2014)

Sampling Stations

10-cm-diameter Clarke-Bumpus net fitted with 154-µm mesh towed obliquely for 10 min from bottom to the surface



Courtesy of CDFW

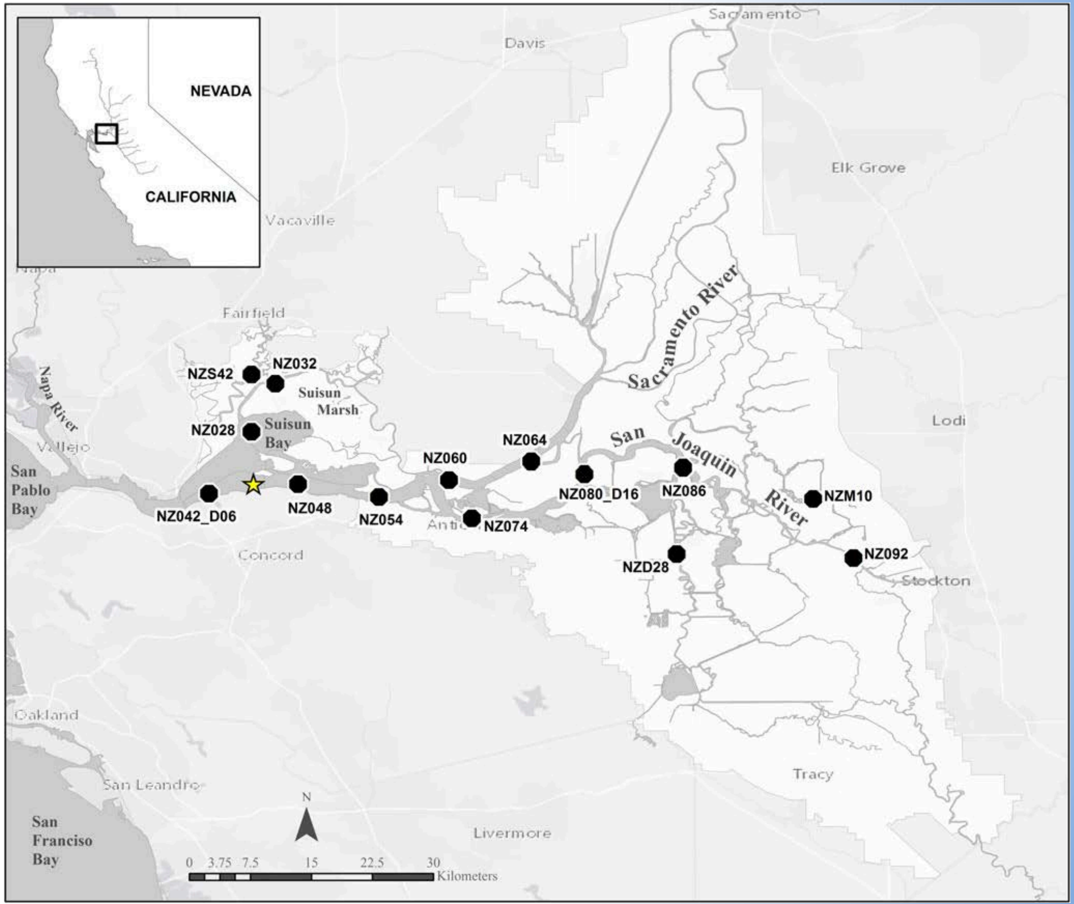
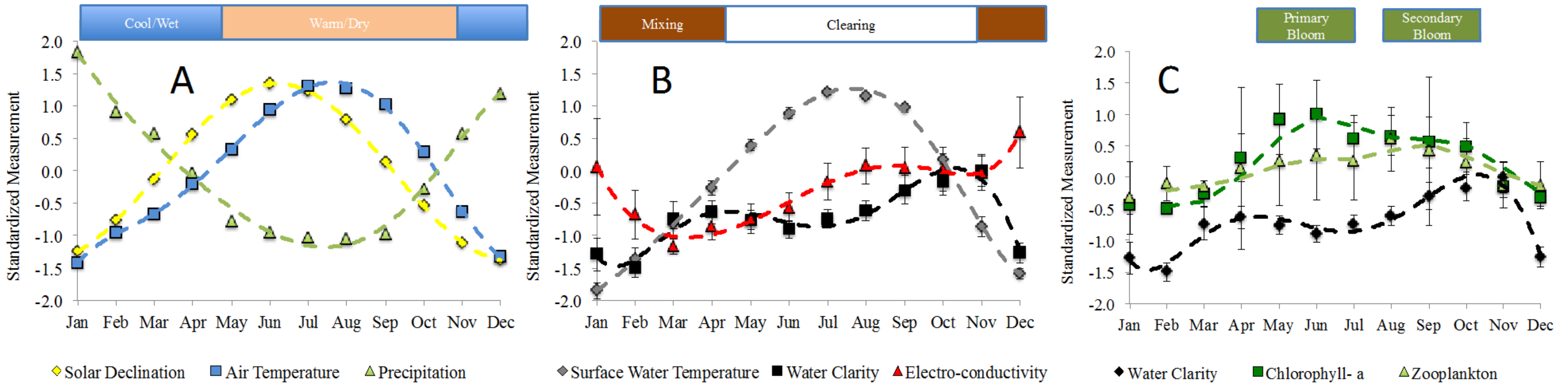


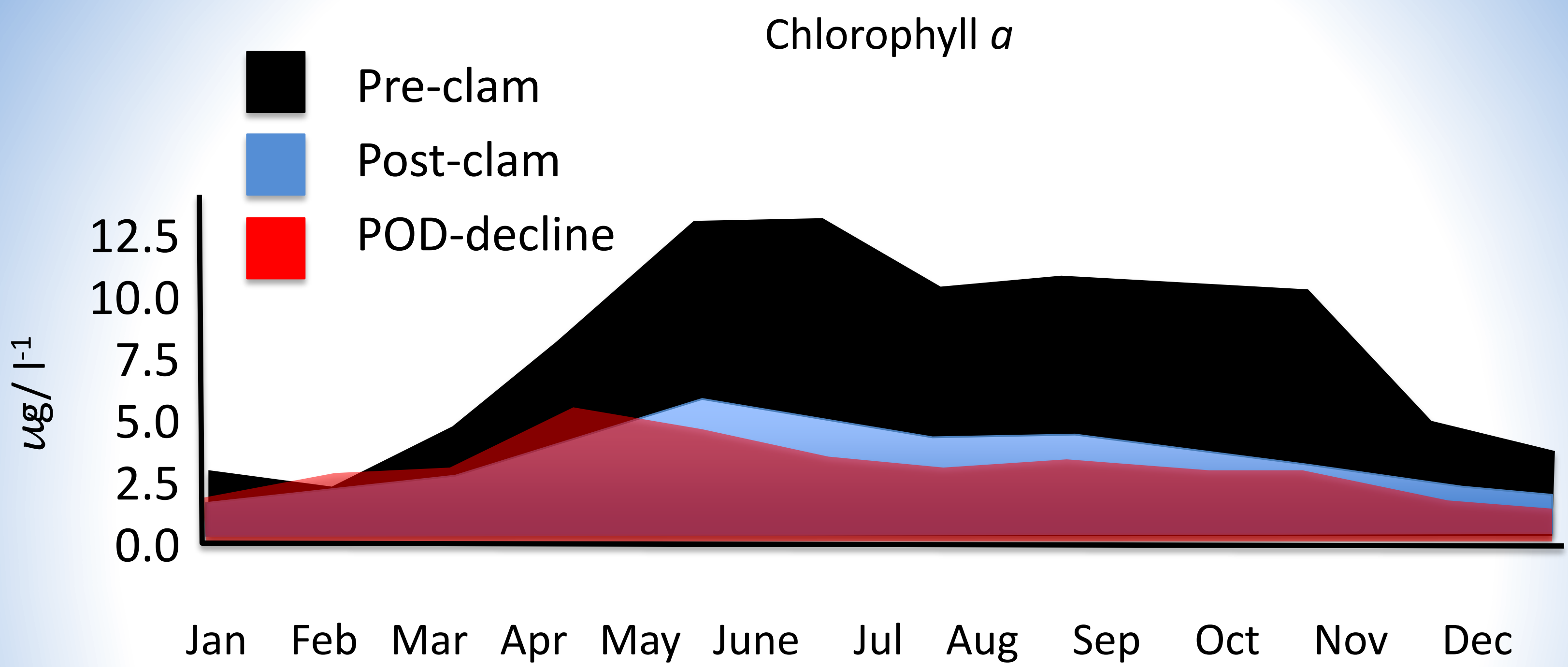
Fig. 1 A map of the San Francisco Estuary, California and 14 zooplankton stations consistently sampled between 1977 and 2014. Dark gray waterway indicates main waterways of the Sacramento-San Joaquin Delta. The star indicates Port Chicago Naval Depot Station

Historic Patterns

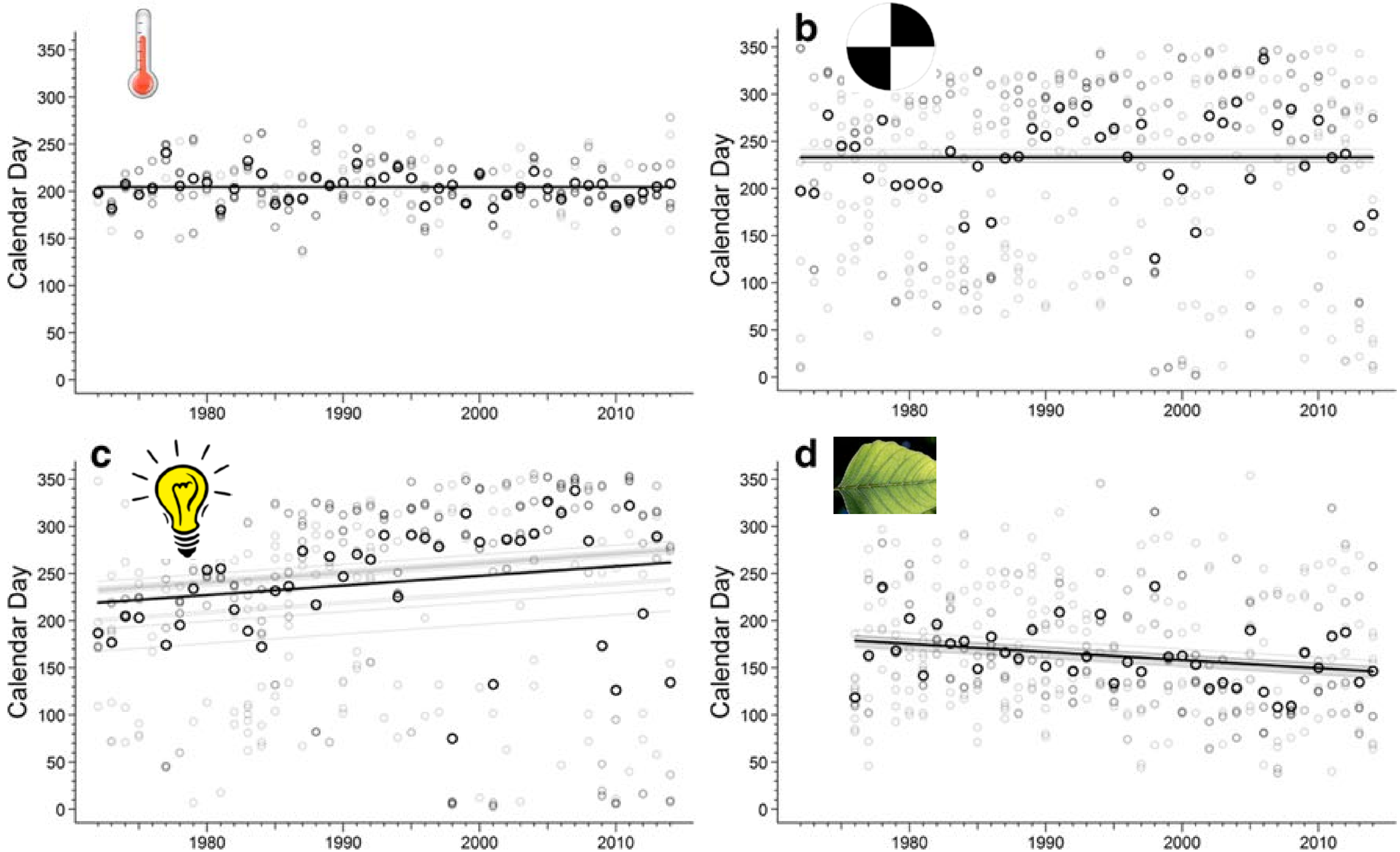


Relationships between the (**a**) primary drivers solar declination and precipitation and mean monthly air temperature for Port Chicago Naval Depot, (**b**) electro-conductivity (EC), water clarity, surface water temperature, and (**c**) primary productivity and zooplankton biomass for the 15 zooplankton stations monitored during the pre-clam invasion period (1978–1985). *Lines* represent the locally weighted scatterplot smoother (Lowess), which is the locally weighted fit of the simple curve at sampled points in the domain (Cleveland 1979). Means are standardized for comparisons and presented as *Z* scores

Before invasion by the suspension-feeding overbite clam in mid-1980s, the Estuary demonstrated monomictic thermal mixing in which winter turbidity and cool temperatures contributed to seasonally low productivity, followed by a late-spring-summer clearing phase with warm water and peak phytoplankton blooms that continued into early winter.



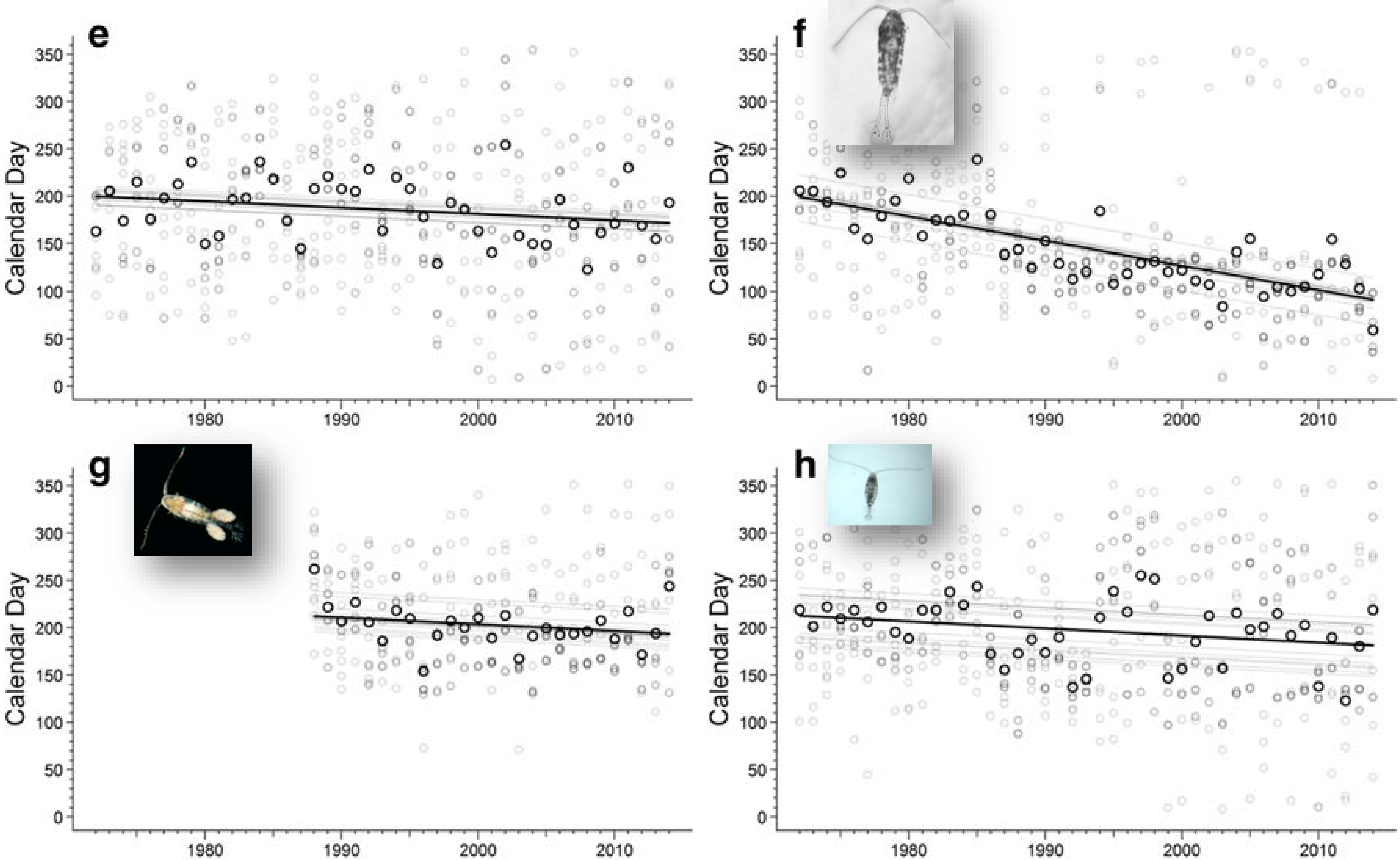
Earlier peak phytoplankton bloom timing, with peak productivity now occurring in May compared to June prior to the invasion.



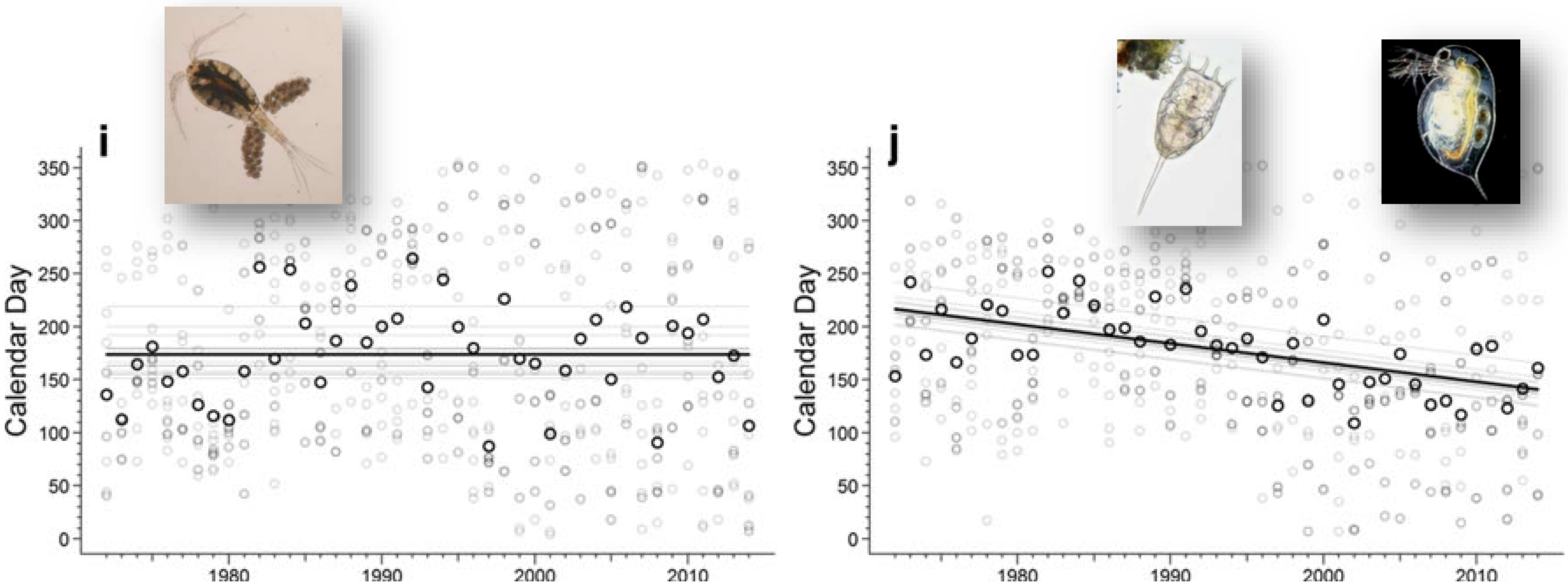
Timing of the annual maximal value for (a) temperature, (b) Secchi depth, (c) electrical conductivity, (d) chlorophyll-a. gray points are dates of yearly maxima for each station and black points are the among-station averages. Lines represent best-fit

Following clam invasion:

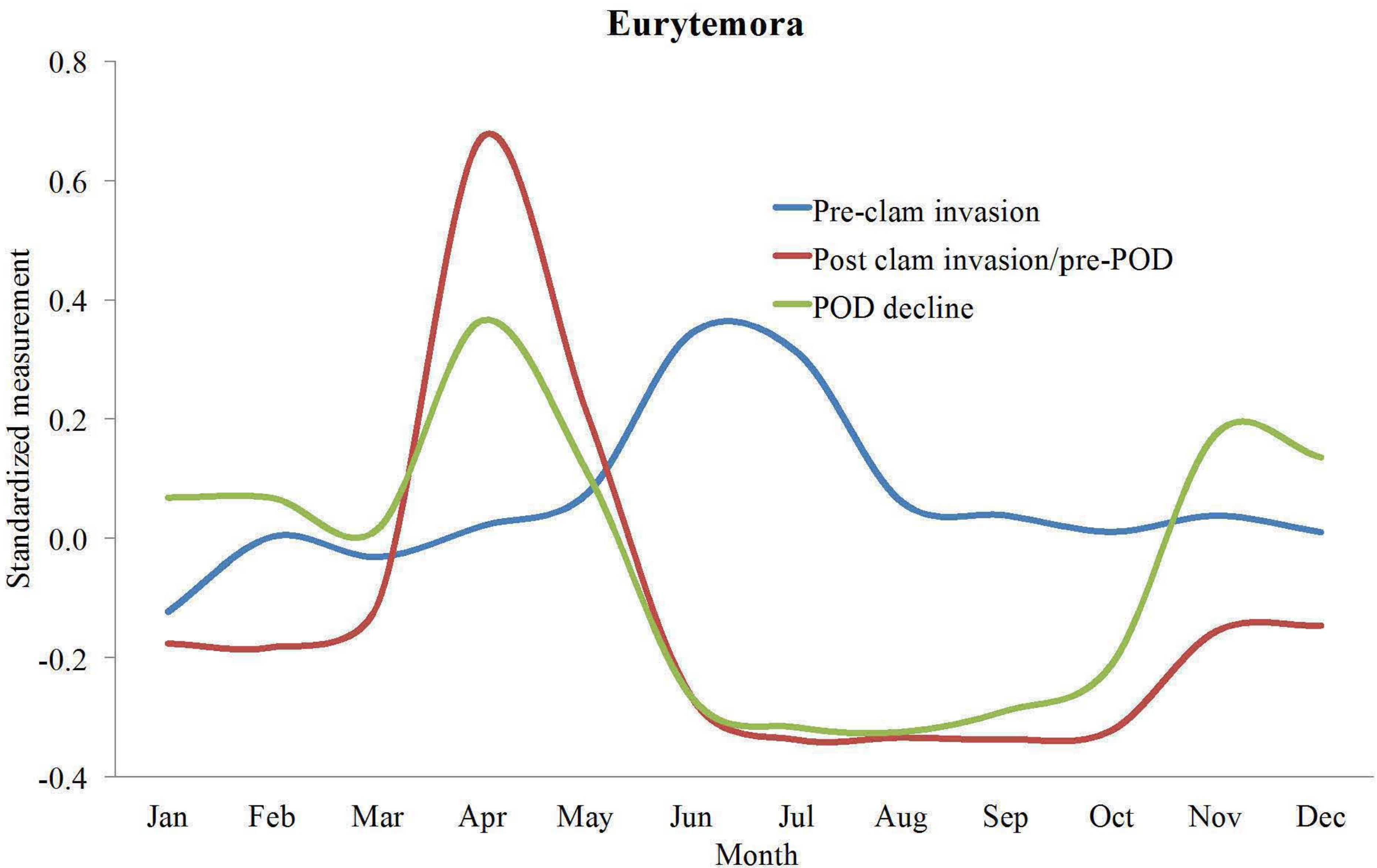
- shift to later electrical conductivity
- earlier peak phytoplankton bloom timing, with peak productivity now occurring in May compared to June prior to the invasion.



Timing of annual maximal value for (e) total zooplankton, (f) Eurytemora, (g) Pseudodiaptomus, (h) other calanoids. Gray points are dates of yearly maxima for each station and black points are among-station averages. Lines represent best-fit LMM: black line represents among-station average fit, and gray lines represent station-specific fits. Peak abundance of several zooplankton taxa (Eurytemora affinis, Pseudodiaptomus, other calanoids, and non-copepods) also shifted to earlier in the season.



Timing of annual maximal value for (i) cyclopoids, and (j) non-copepods.
Gray points are dates of yearly maxima for each station and black points are the among-station averages. Lines represent best-fit LMM: black line represents among-station average fit, and gray lines represent station-specific fits.



Peak abundance of *Eurytemora affinis*, shifted to earlier in the season, including a possible shift from a univoltine to divoltine life cycle?

Study highlights

- Importance of a long series of frequently and consistently collected data
- Food web interactions associated with sequential perturbations, including non-native species introductions
- Results provide the first indication of the extent that seasonal synchronicity in Estuary predator and prey timing has been altered, providing a better understanding of the challenges facing delta smelt recovery and the overall Estuary health.
- Revealed large shifts in chlorophyll-a concentration and phenology of four zooplankton taxonomic groups (Eurytemora, Pseudodiaptomus, other calanoid, and non-copepod abundance)
- In all cases, biological responses occurred earlier in the year across the 43-year period.
- Confirms detailed timing shifts in peak key zooplankton abundance in Estuary.

Future research

Study provided insight into limnological and zooplankton responses to serial perturbations, but did not adequately reveal linkages between observed changes and delta smelt status since the introduction of the overbite clam.

Future habit studies should explore mechanisms linking temporal and spatial variability of prey presence with delta smelt distribution and abundance.

Future conservation efforts should consider restoring timing and magnitude of historical, pre-invasion phytoplankton blooms.

We gratefully acknowledge

- CDFW for many years of data collection and dissemination
- Jenny Melgo for data query and analysis
- P. Rueger for GIS spatial analyses and figure development support
- Funding for this project was provided by the Center for California Water Resources Policy and Management