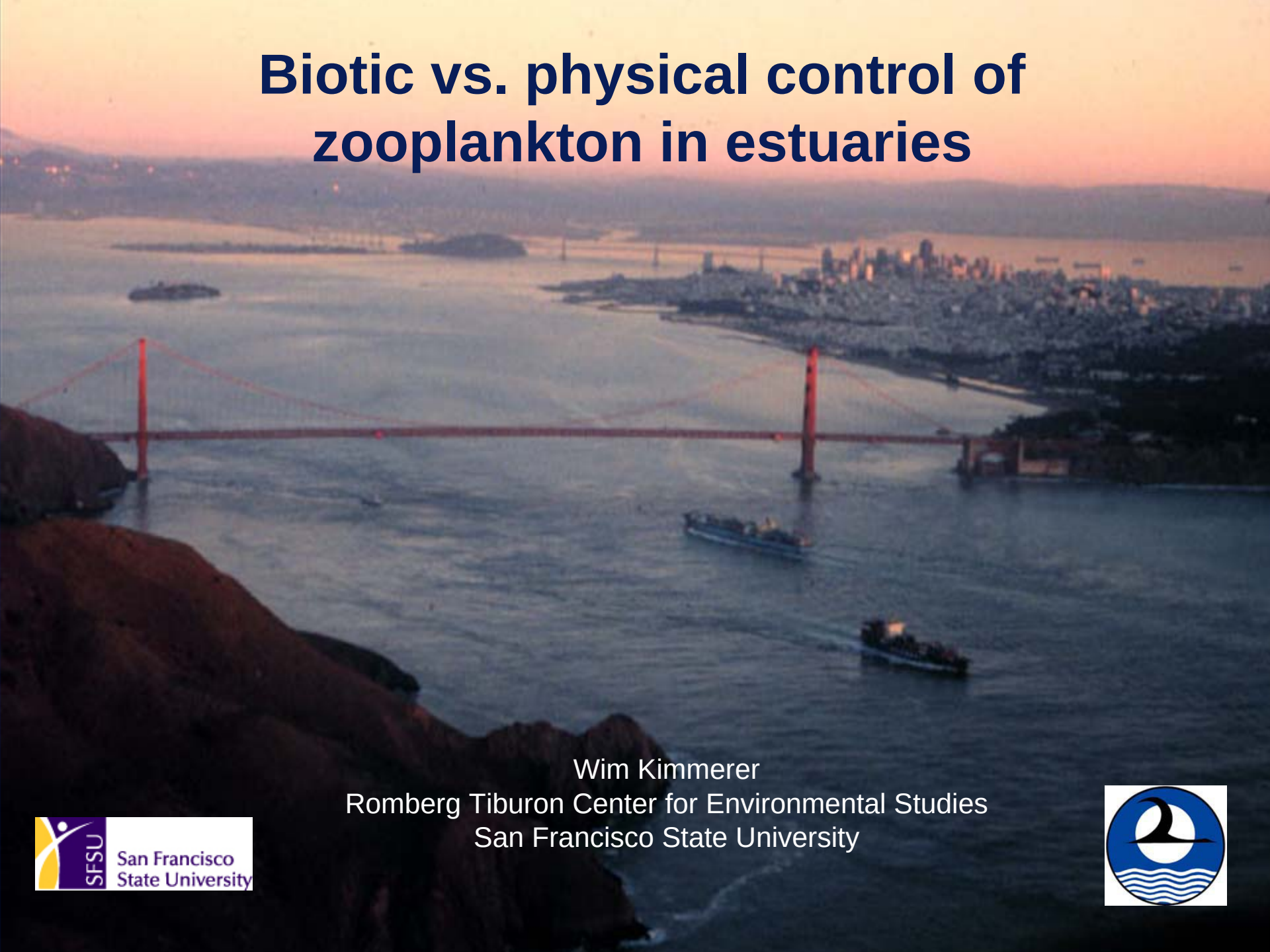
Biotic vs. physical control of zooplankton in estuaries



Wim Kimmerer
Romberg Tiburon Center for Environmental Studies
San Francisco State University

SFSU San Francisco State University

Outline

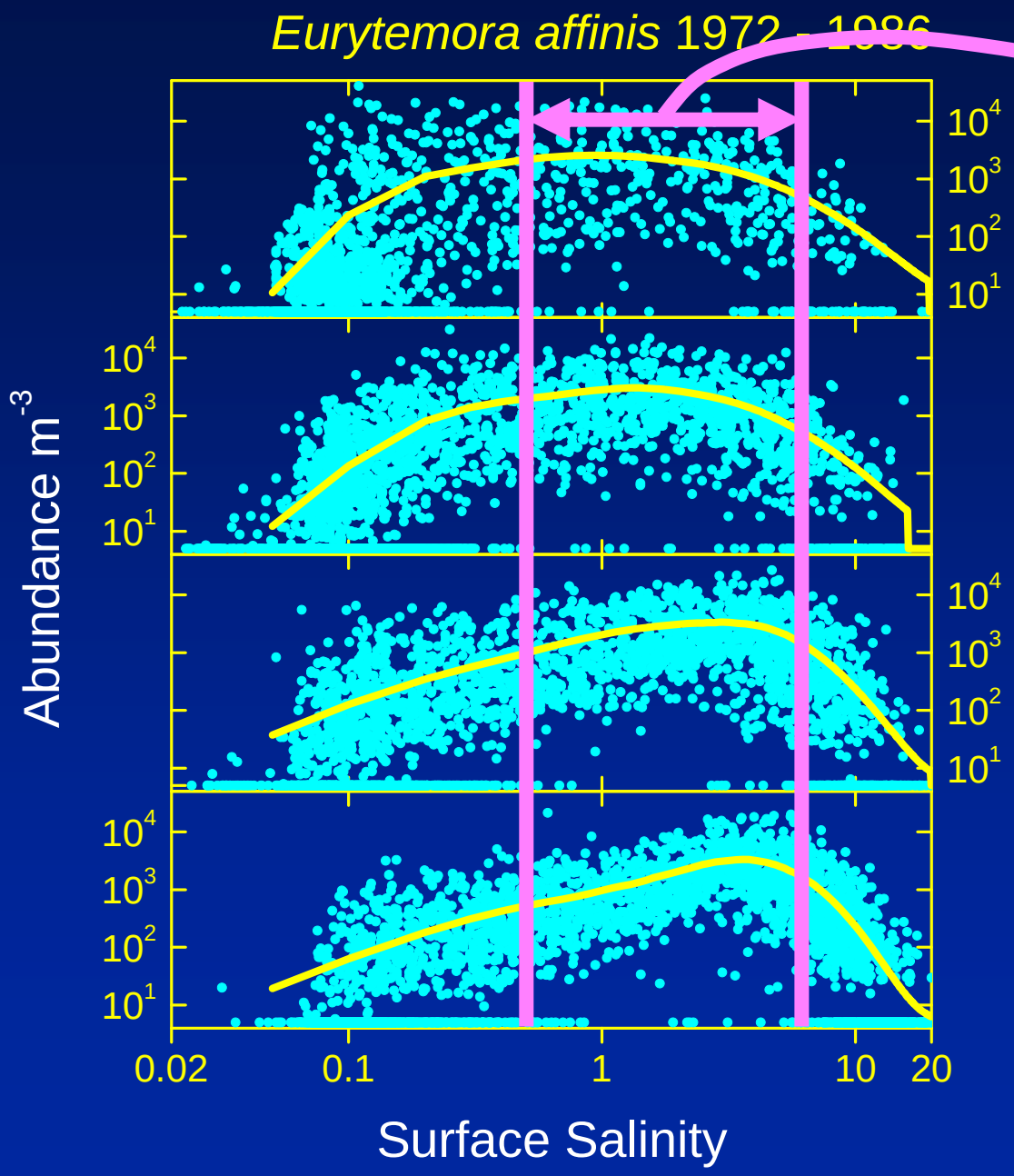
- Physical conditions for zooplankton
- How they cope
- Evidence for biotic control
- Top down or bottom up?
  - A false dichotomy

Examples from our work in the upper San Francisco Estuary and from the literature

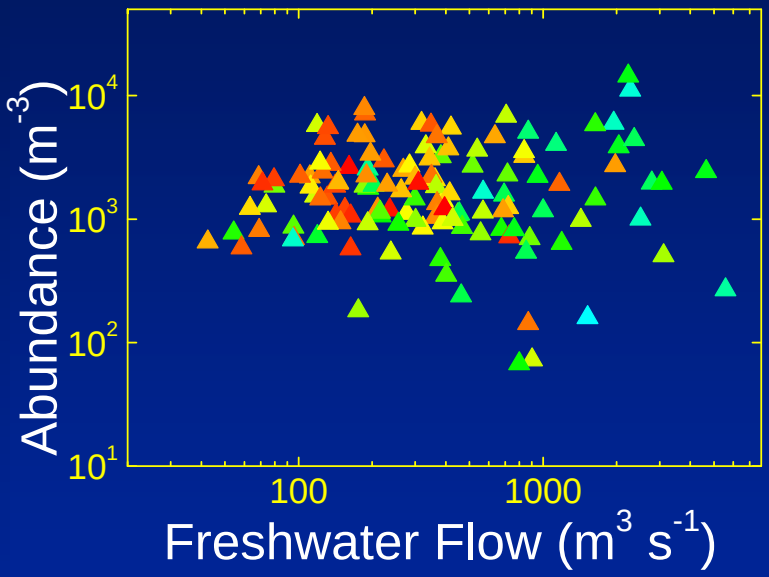
Challenges for Estuarine Zooplankton

- Seaward residual flow
- Tidal mixing
- Salinity gradient
- Shallow water
- Things people do

Distributions in salinity space

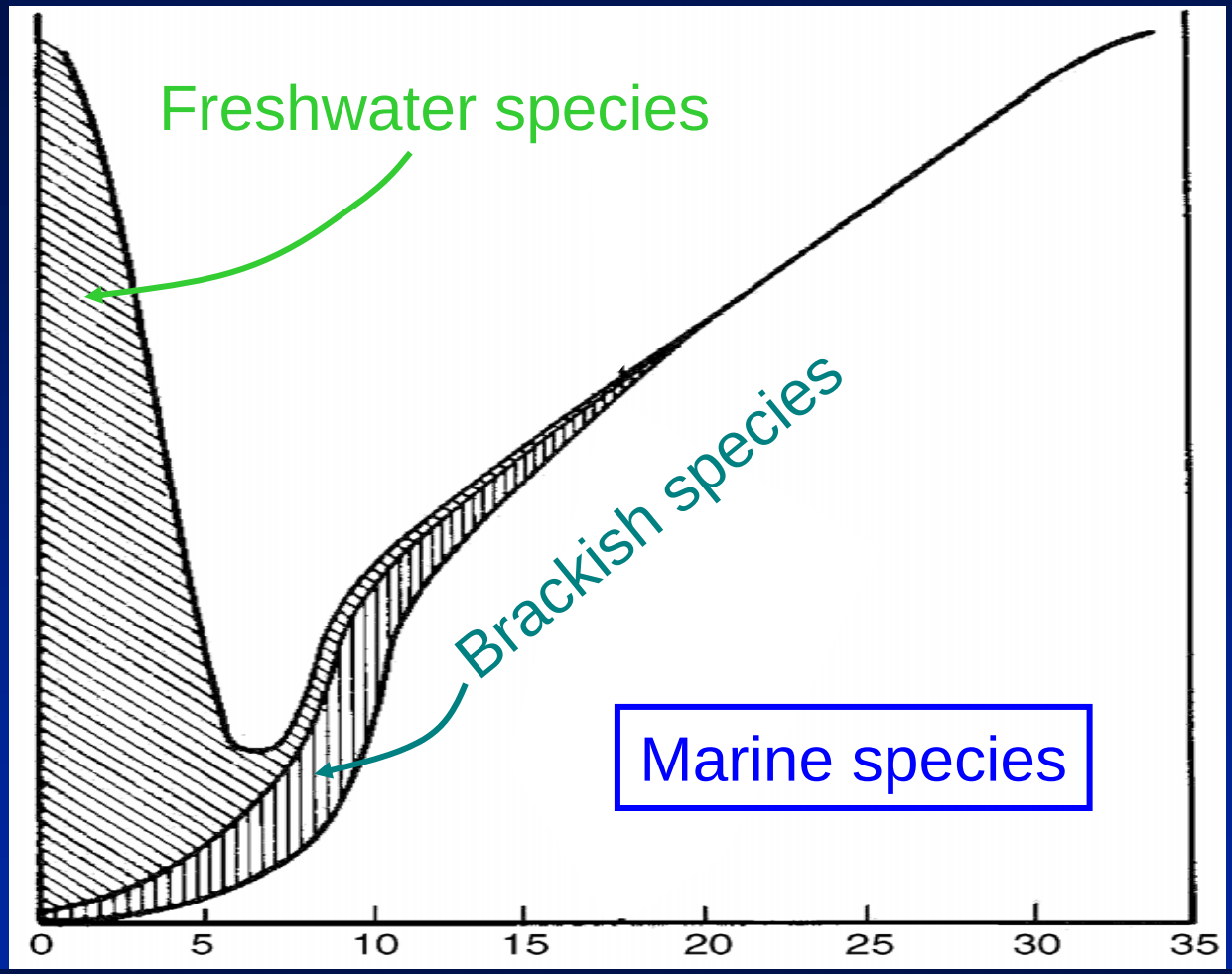


Abundance at S= 0.5 – 6 (color = Temperature)



See:
Laprise & Dodson
1993 MEPS

Distributions in salinity space: the Remane diagram



Number of Species

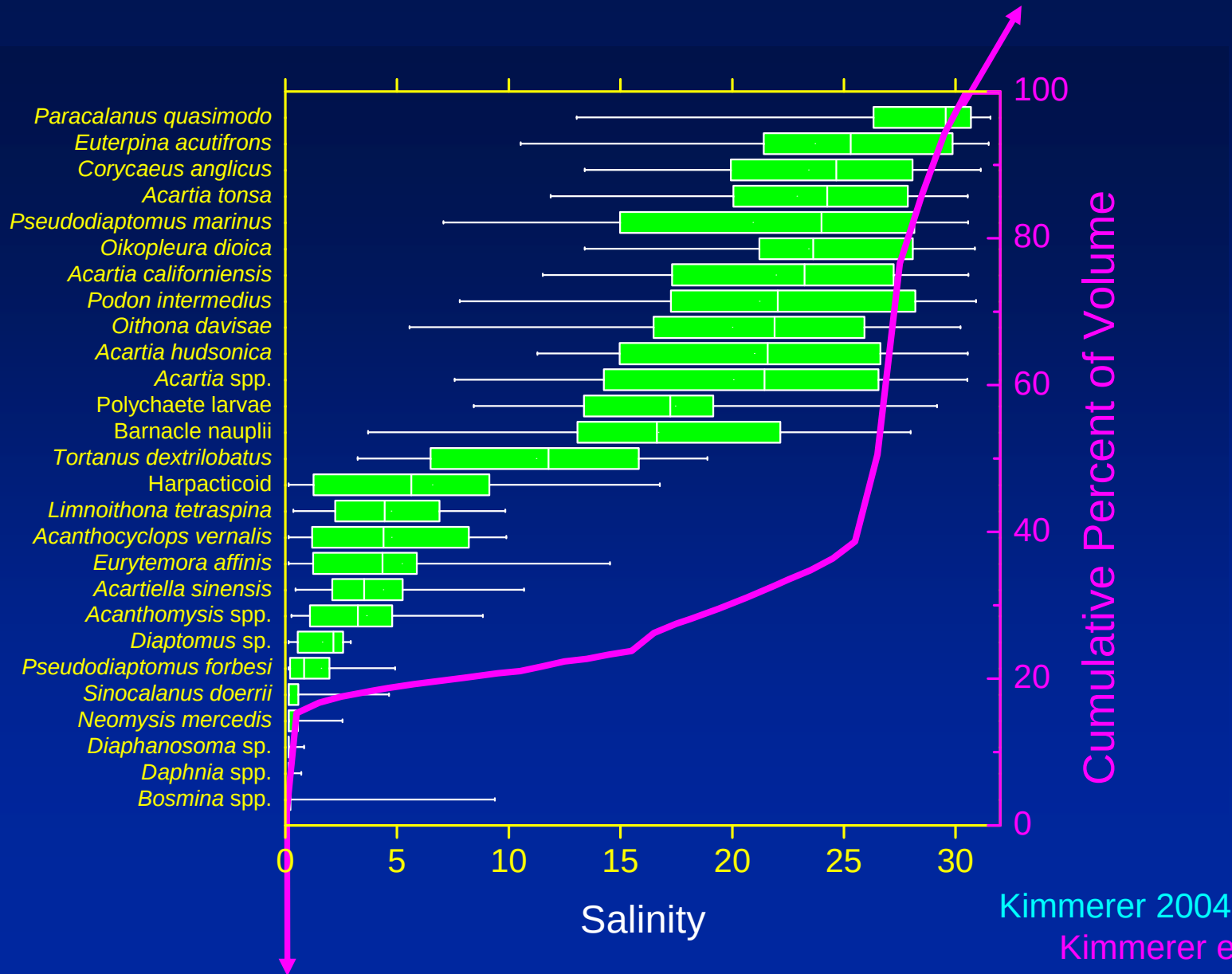
Salinity

Benign ⟷ Harsh? ⟷ Benign

Distributions in salinity space

San Francisco Estuary, 1997-1999

Intermediate-salinity habitat is smaller than freshwater or marine habitat

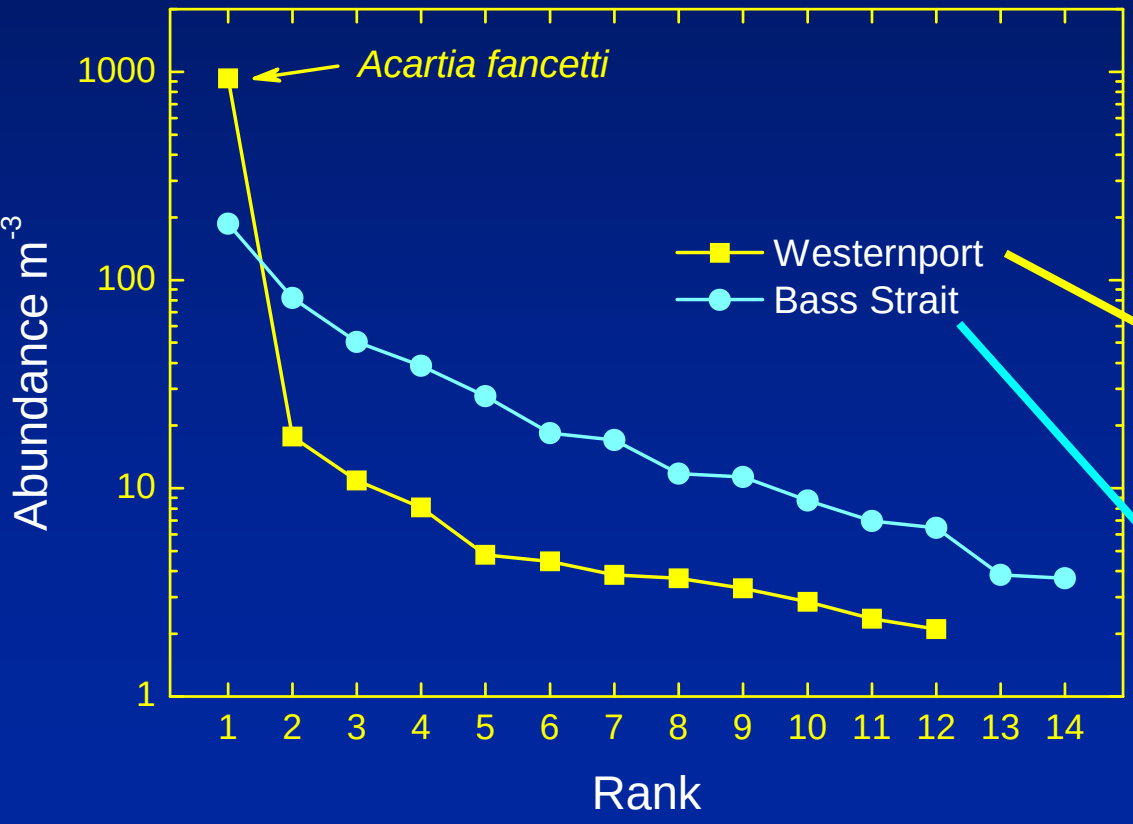


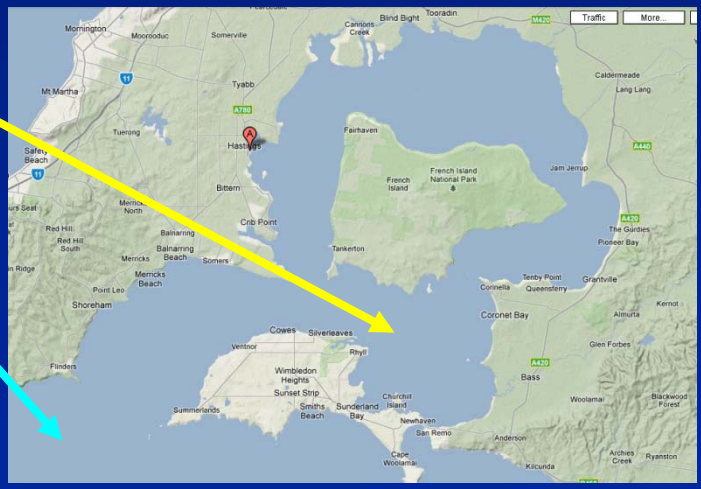
Kimmerer 2004 SFEWS & unpubl.
Kimmerer et al. 2009 E&C

Species distributions I

Species abundance curves in southern Australia

Low diversity within bay despite high salinity
Similar patterns in several Japanese estuaries
(Ueda 1991 Bull. Plankt. Soc. Japan)

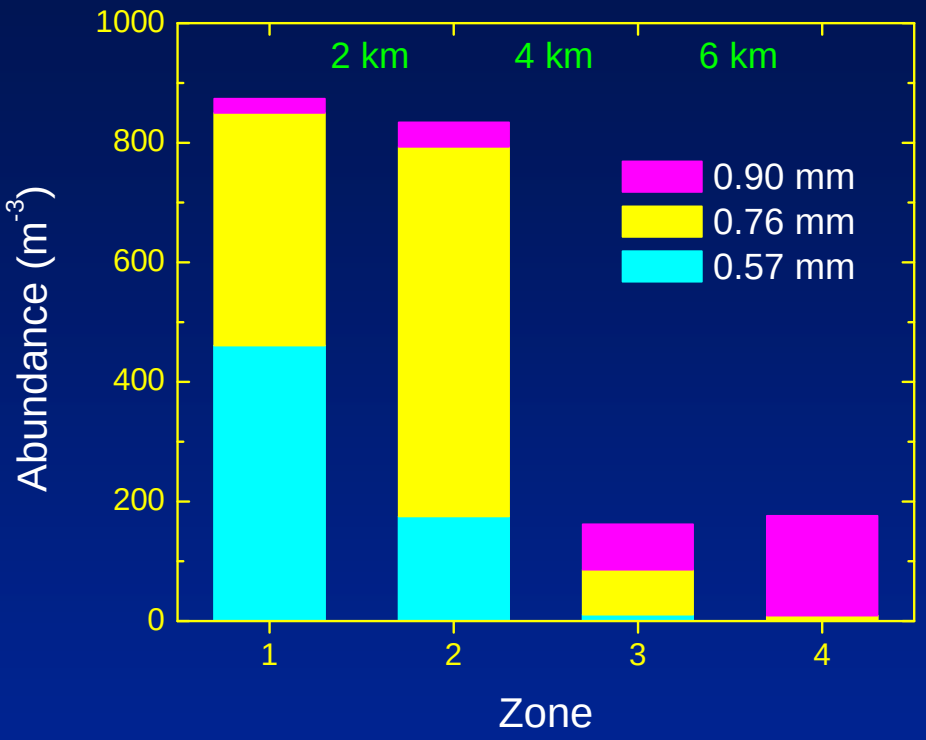




Kimmerer & McKinnon 1985 ECSS

Species distributions II

Acartia congeners in high-salinity estuaries



Inner Bay → Outer Bay

Similar patterns in:

Maizuru Bay, Japan (Ueda 1987 ECSS)

Westernport, Australia (Kimmerer and McKinnon 1989 MEPS)

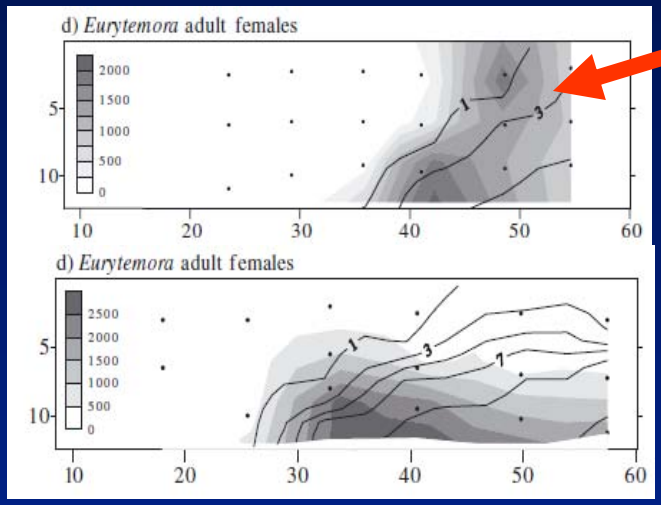
Tomales Bay, CA (Kimmerer 1993 Estuaries)

Alcaraz 1983 JPR

Distributions in salinity space: *E. affinis*

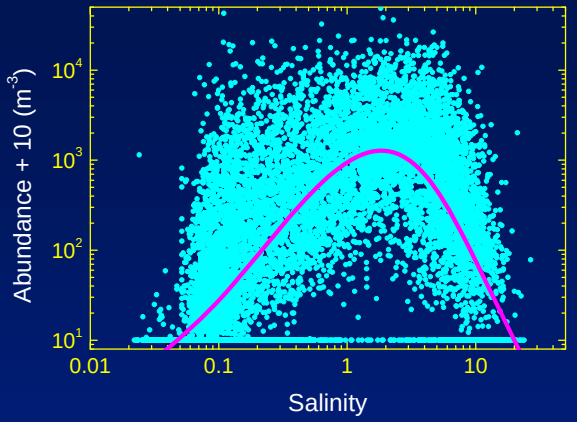
Kimmerer et al. 1994 MEPS

North and Houde 2003 MEPS



Depth, m

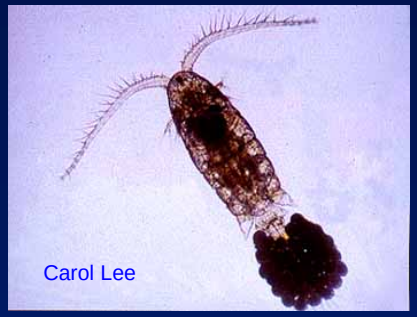
salinity



Kilometers from River Mouth

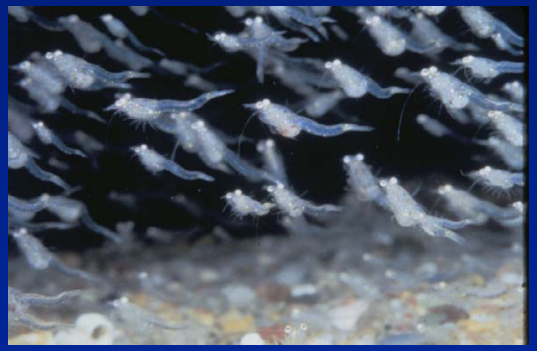
BUT:
Physiologically they do better at 5 – 30
Roddie et al. 1984 JEMBE
Kimmel & Bradley 2001 JEMBE
Devreker et al. 2004 JEMBE, 2007 JPR
Cailleaud et al. 2007 Comp. Biochem.

How to Avoid Dispersive Losses



Produce resting eggs

Be prolific



Migrate tidally

Migrate to the bottom

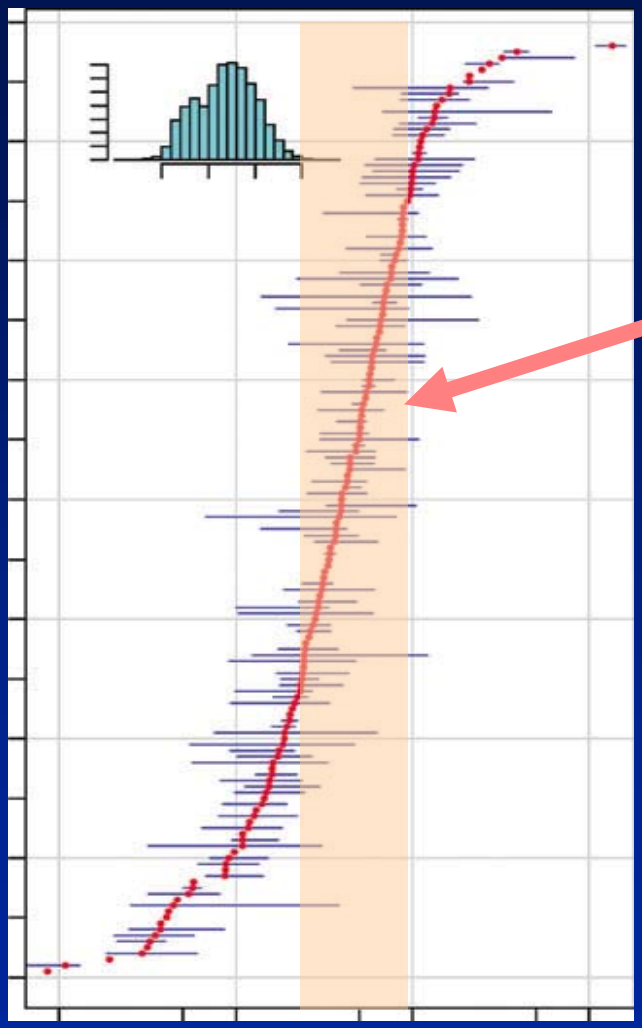
Stay near the bottom

Migrate dielly
(with suitable phasing)

“Estuaries are some of the most productive ecosystems in the world”

http://www.estuaries.gov

Chlorophyll in estuaries and coastal waters



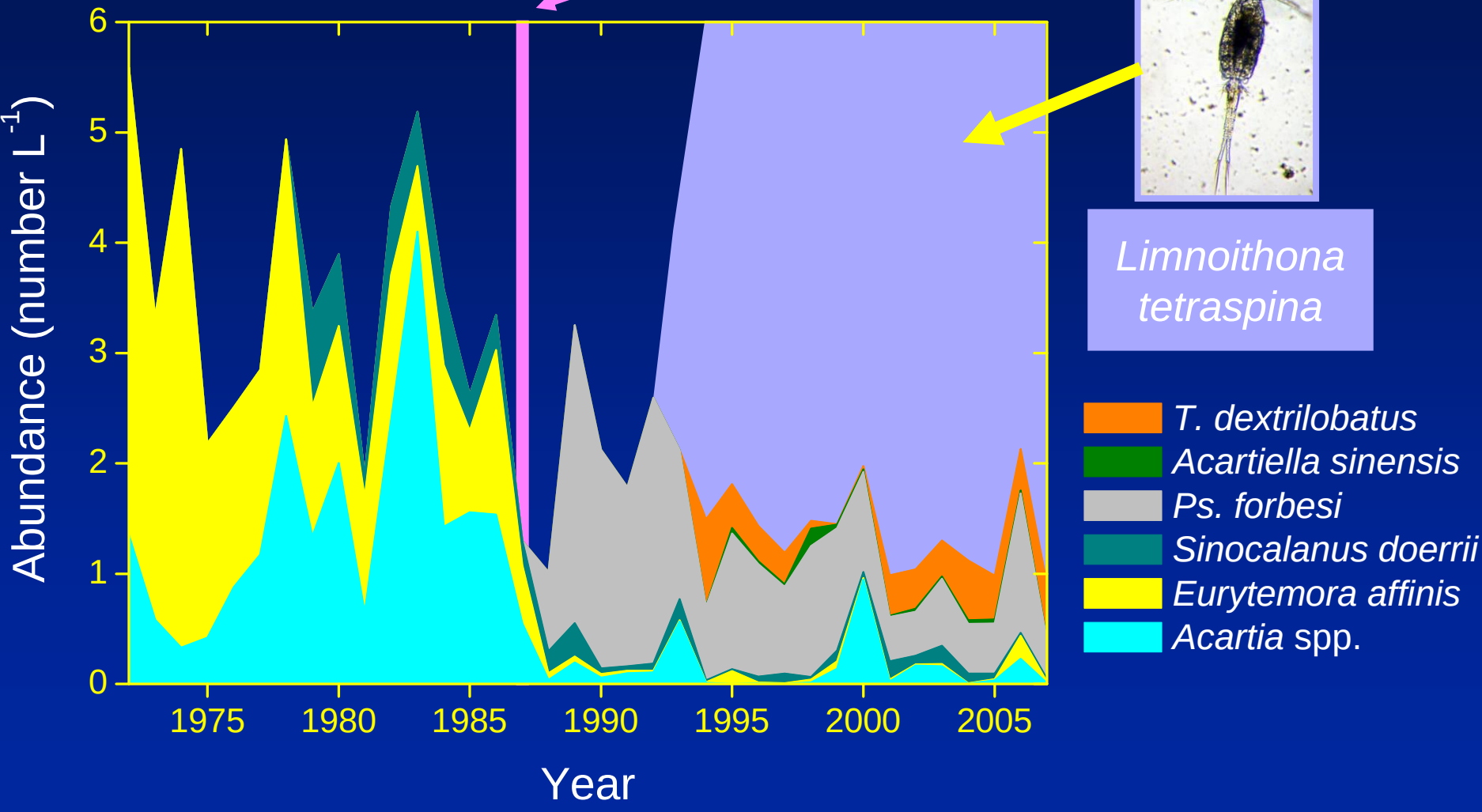
Onset of food limitation

North America	63
Europe	50
Asia	19
Australia/NZ	9
South America	8
Pacific	4
Israel	1

Cloern and Jassby 2008 Ecol. Letters

Evidence for Biological Control I

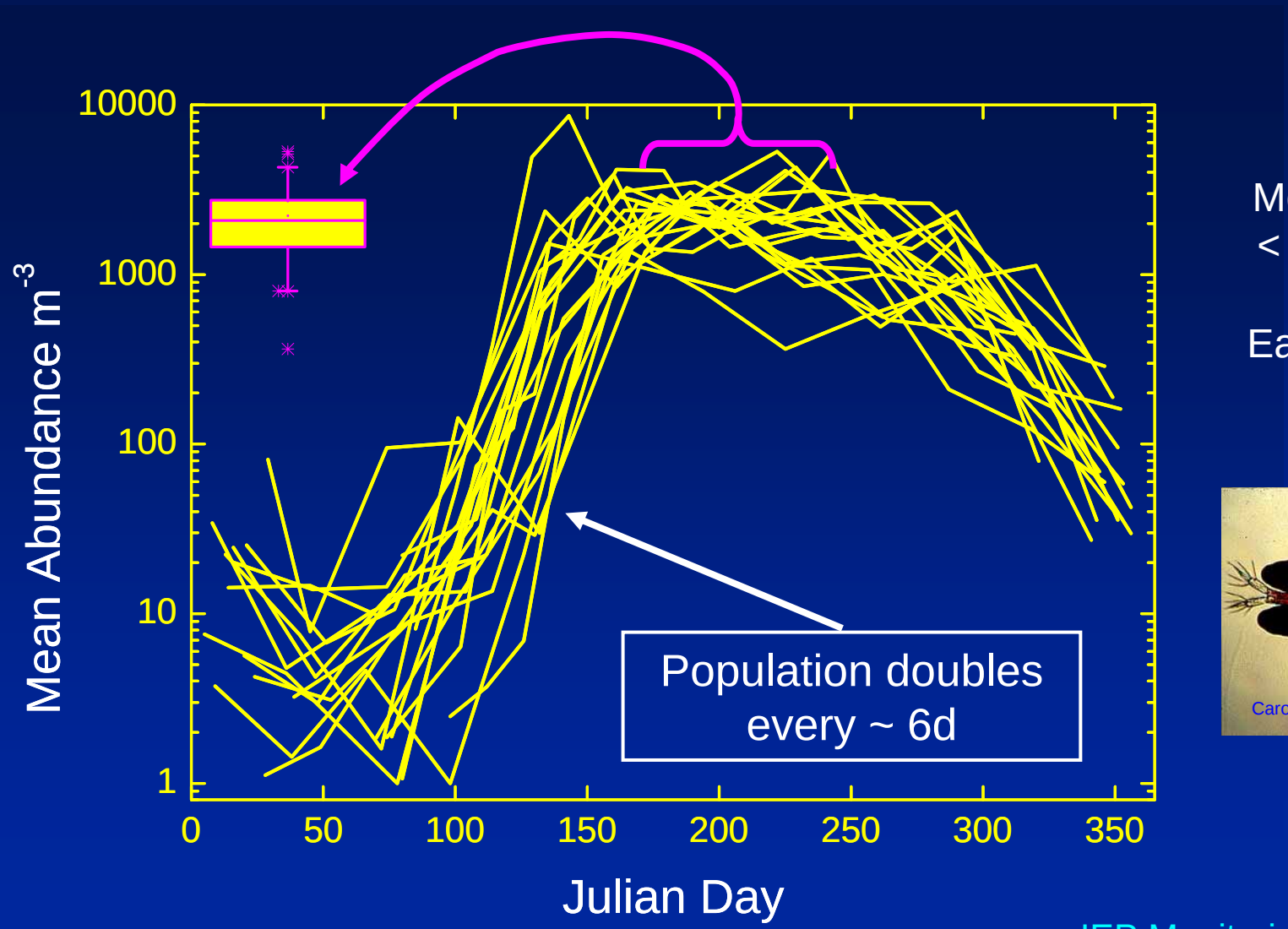
Abundance in Low-Salinity Zone



IEP Monitoring Data

Evidence for Biological Control

Pseudodiaptomus forbesi adult abundance in freshwater: 1989 – 2008



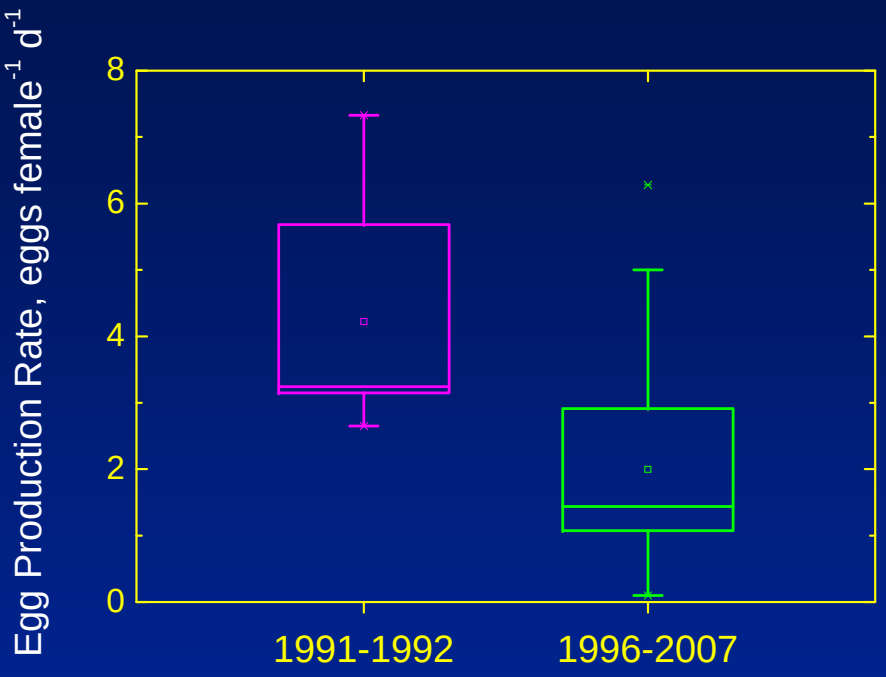
Means for salinity < 0.5, all stations

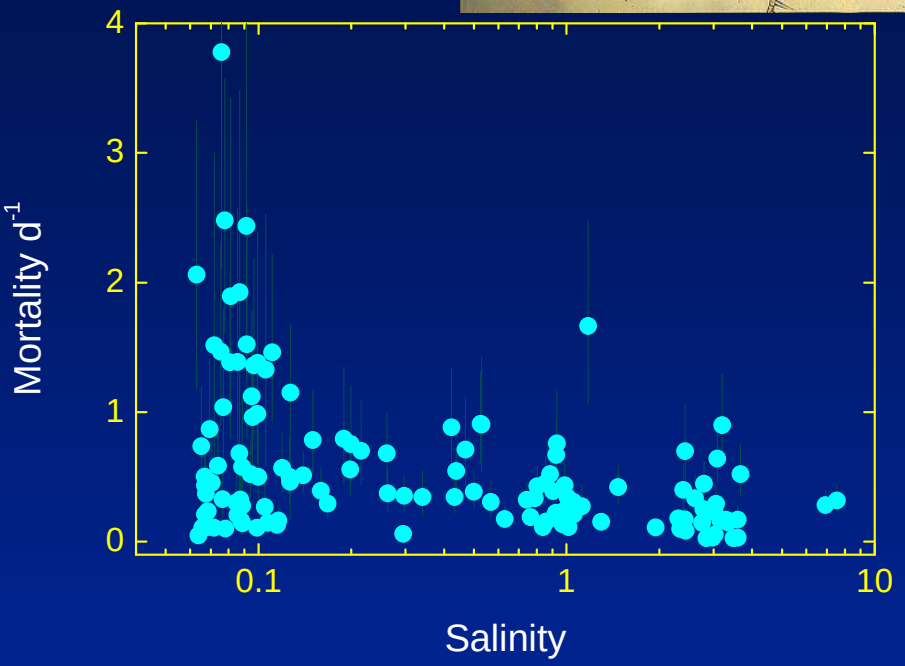
Each line = 1 year

IEP Monitoring (A. Hennessey)

Birth and Death in an Estuary

Pseudodiaptomus forbesi



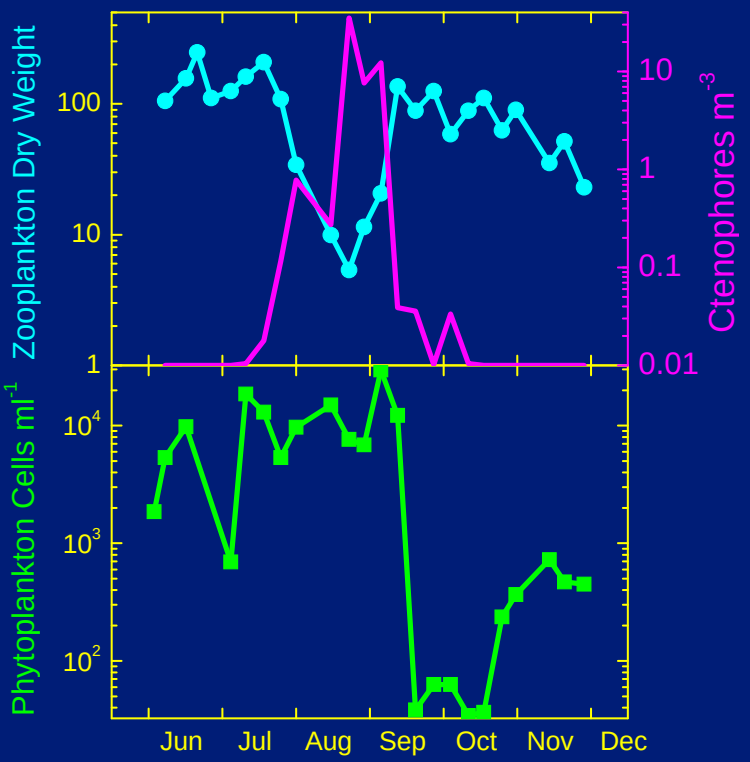


Egg production declined after introduction of 2 other spp.: Competition? Predation?

Very high mortality of adults in freshwater: vertebrate predation?

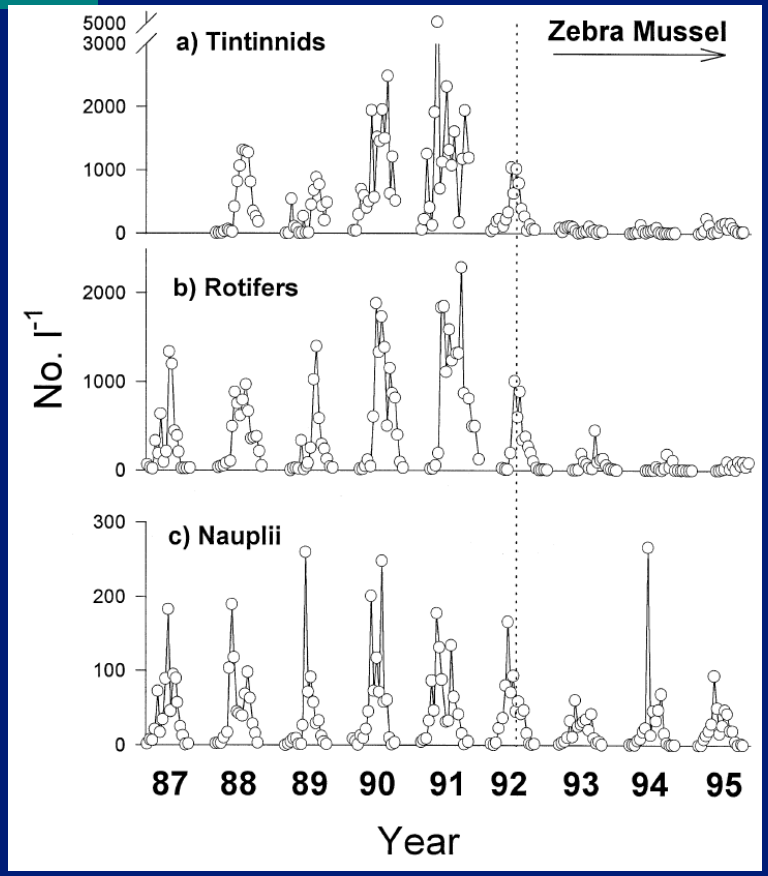
See posters: A. Slaughter S2-7082 and T. Ignoffo S2-7119

Predatory Effects on Zooplankton



Apparent control of mesozooplankton abundance by gelatinous predators Narragansett Bay, 1974

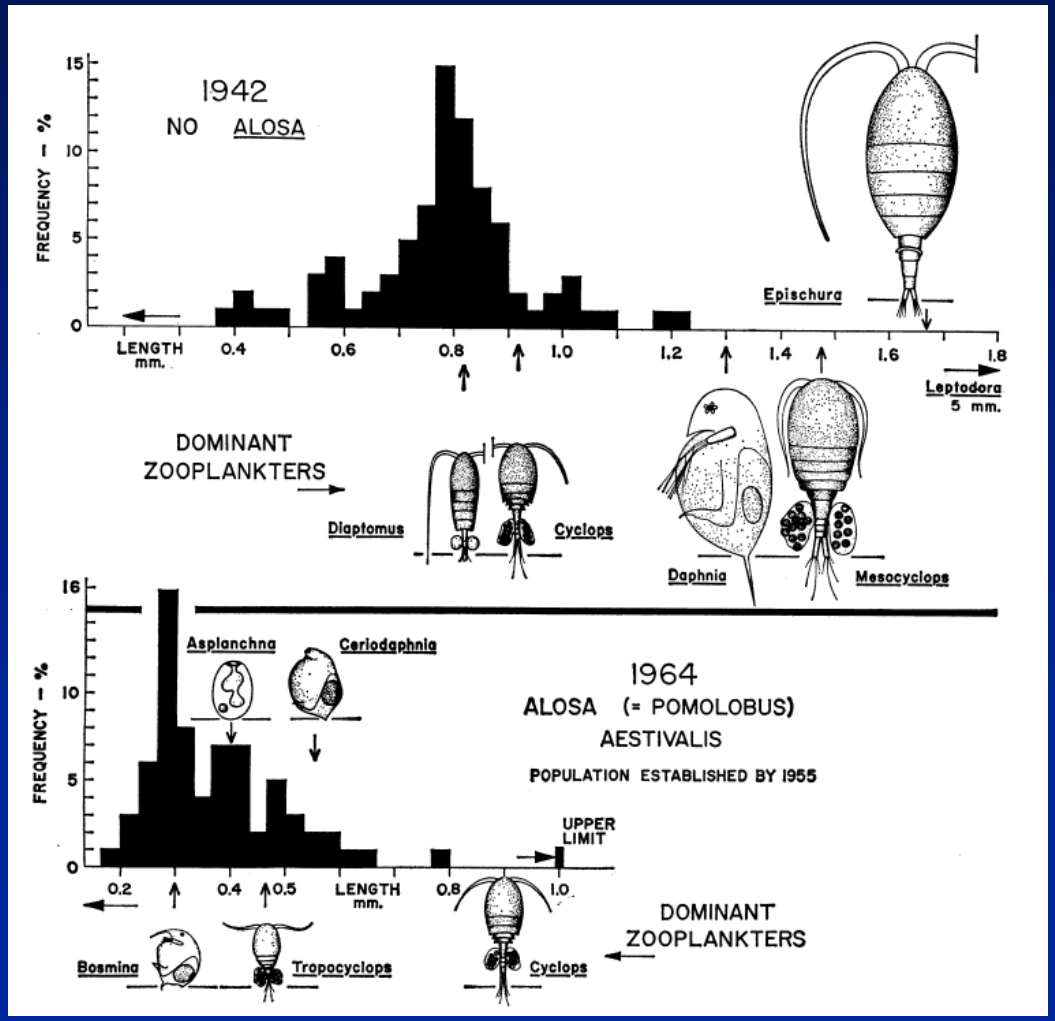
Deason & Smayda 1982 JPR



Apparent control of microzooplankton abundance by zebra mussels Hudson River

Pace et al. 1992 Freshw. Biol.

What are the effects of vertebrate predation?



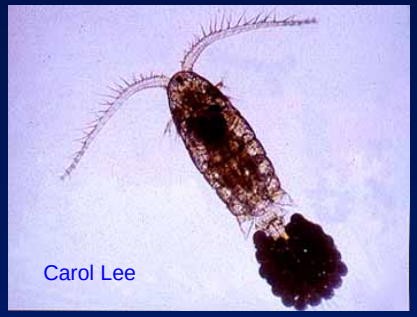
Birth of the “size efficiency hypothesis”

Invasion of a lake by alewives shifted the zooplankton to a smaller size distribution

Brooks and Dodson 1965 Science

1750 citations

How to Deal with Predators

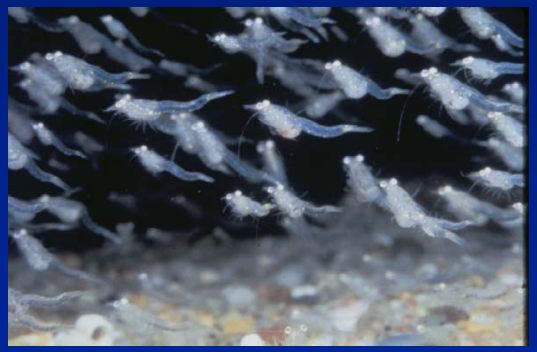


Stay in turbidity maximum

Be small
Be still

Avoid the surface
Be prolific

Stay near the bottom



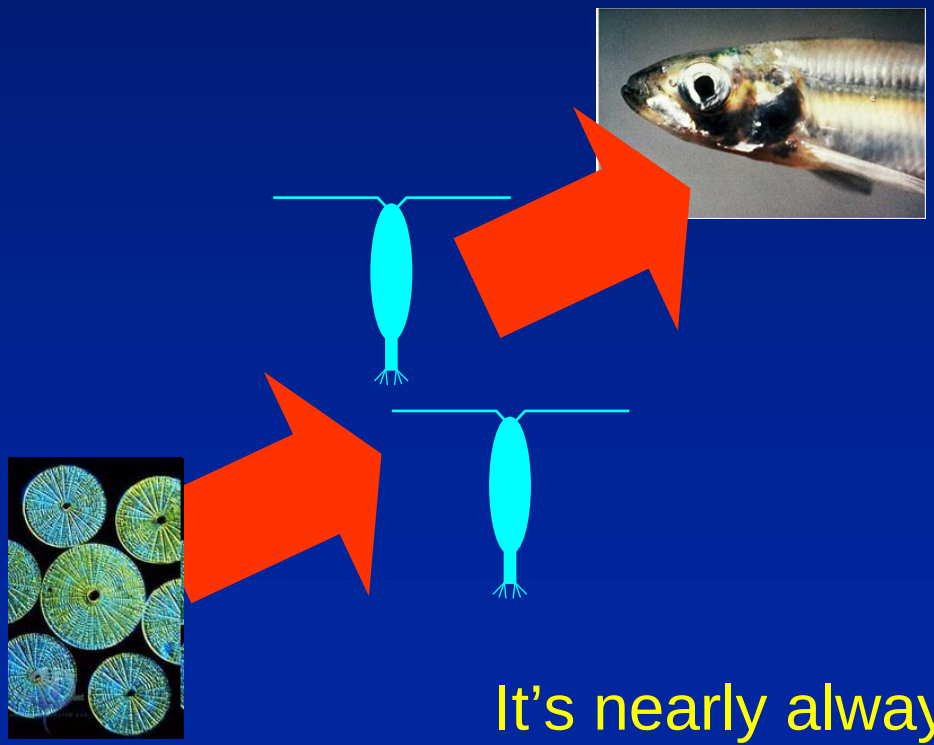
Feed at night

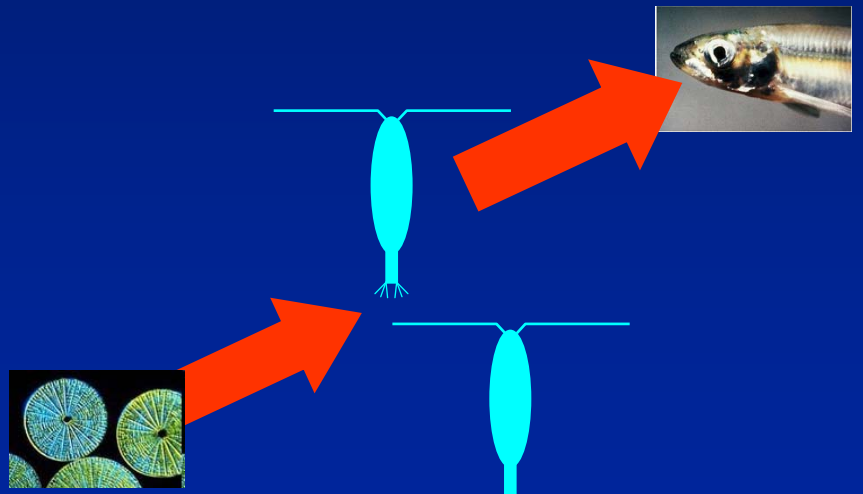
Migrate to the bottom

Migrate dielly

Armor?
Resting stages?

Top-down vs. Bottom-up:
a false dichotomy





It’s nearly always both at once!

Top-down vs. Bottom-up

- Food limitation → population growth rate
- Losses incl. predation → species & size distribution
- Depends on modes of loss, esp. predation
- Both control abundance

Wanted:
more information on mortality
and its causes

¡Gracias!

Thanks to:
Lindsay Sullivan
Toni Ignoffo
Anne Slaughter

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