

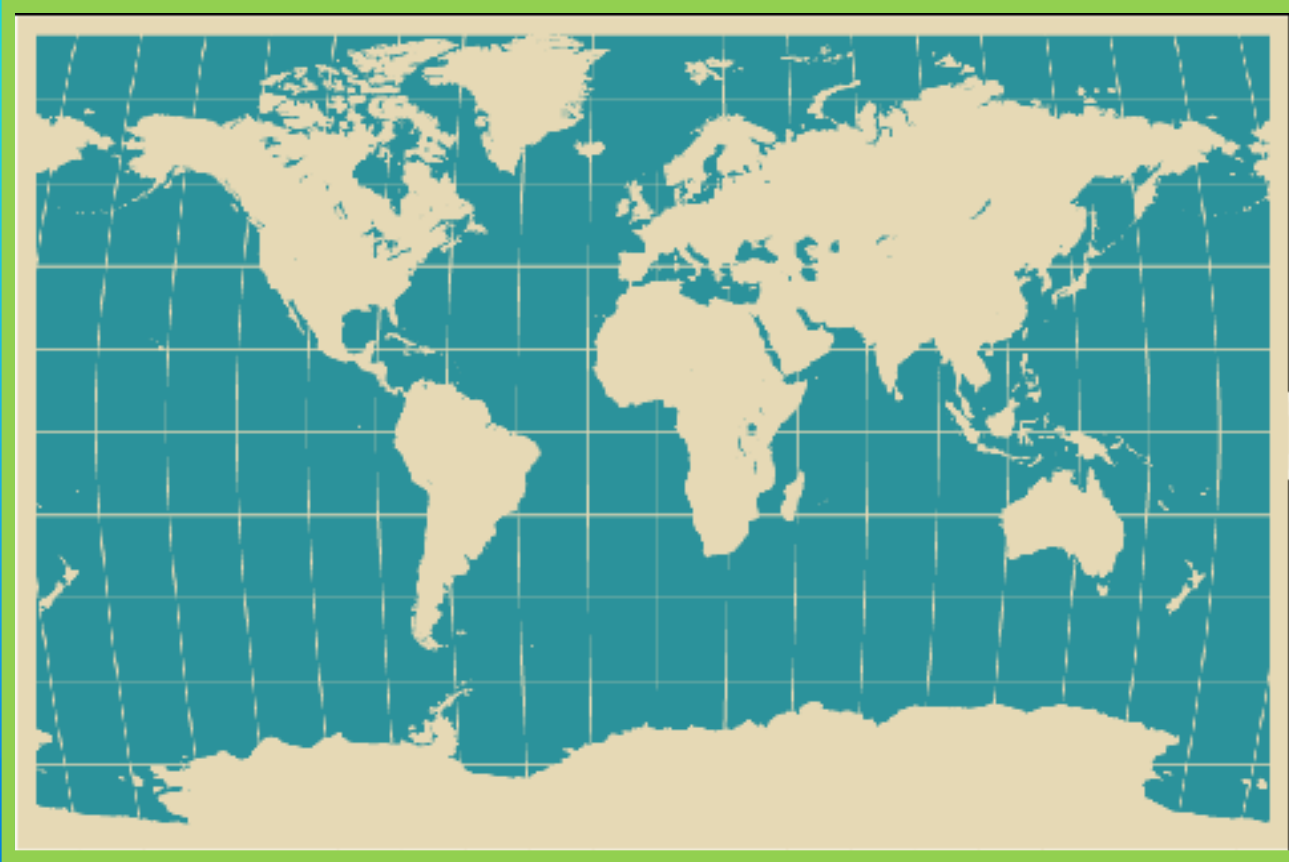
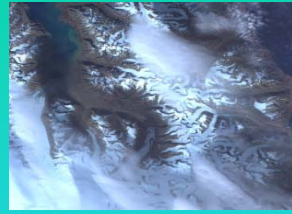
An Assessment of Copepods as Indicator Organisms for Pesticide-Related Toxicity



<http://www.zooplankton-online.net/gallery.html>



Jennifer Kusler
Scientific Aide
Department of Pesticide Regulation
June 29, 2009



Ecological Significance:

- Important in pelagic food chain
- Contribute to nutrient levels in aquatic environments
- Used for disease (vector) control

nauplii



[www.environmentalallevage.com/
Copepods.htm](http://www.environmentalallevage.com/Copepods.htm)

copepodite



www.stetson.edu

Adult copepod



www.edis.ifas.ufl.edu

Life Stages

There are over:

- 240 families
- 2,600 genera
- 21,000 species
- 10 Orders:
 - Calanoida
 - Harpacticoida
 - Cyclopoida
 - Gelyelloida
 - Misophrioida
 - Monstrilloida
 - Mormonilloida
 - Platycopioida
 - Poecilostomatoida
 - Siphonostomatoida



Harpacticoida



Cyclopoida



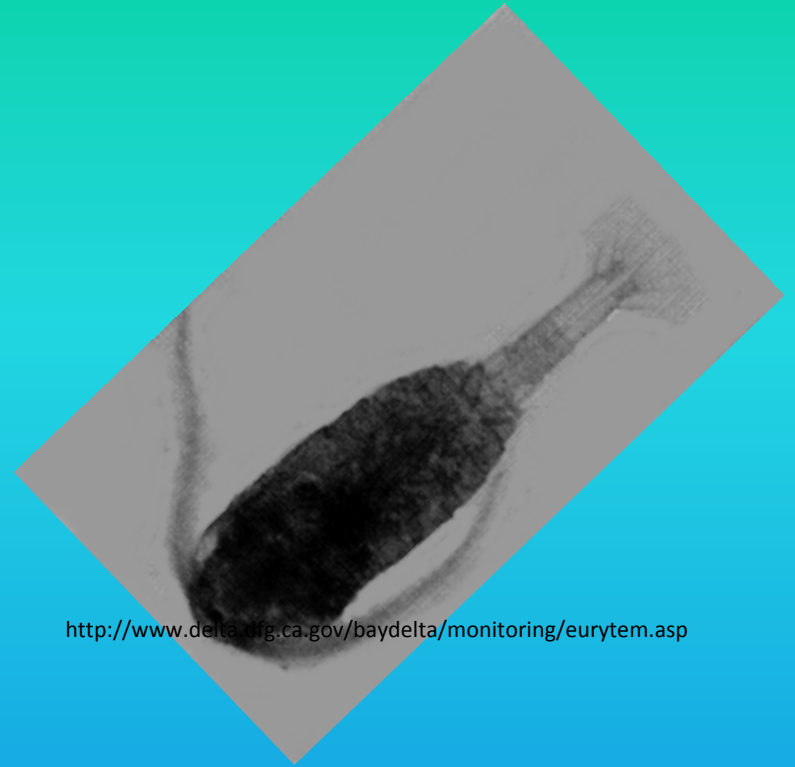
Calanoida

Food Sources:

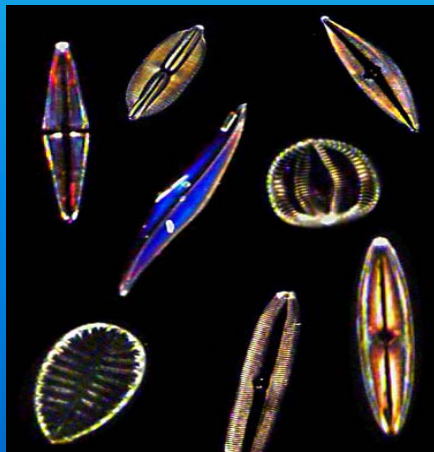
- Algae
- Diatoms
- Dinoflagellates
- Ciliates

Potential Limitations:

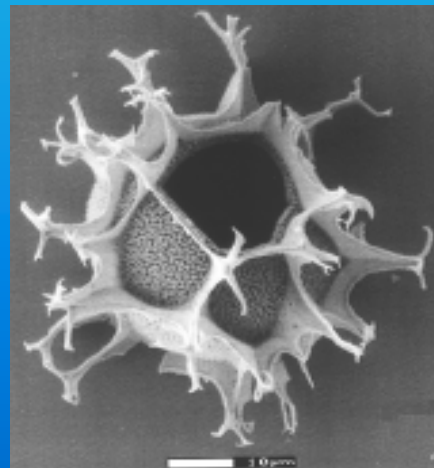
- Quality
- Turbidity
- Competition



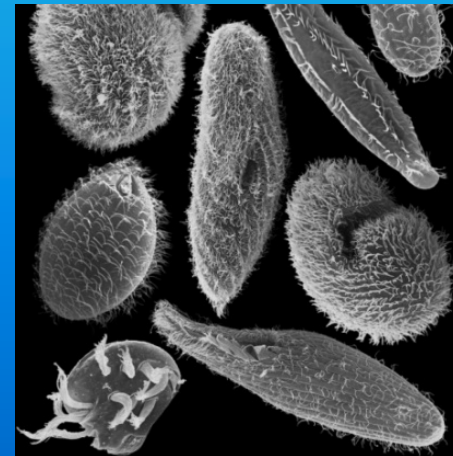
<http://www.delta.dfg.ca.gov/baydelta/monitoring/eurytem.asp>



http://www.viewsfromscience.com/media/photos/Diatom_Composite_v2.jpg



http://www.geo.ucalgary.ca/~macrae/palynology/dinoflagellates/Spiniferites_half.gif



http://www.nsf.gov/od/lpa/news/03/images/fukami_morin1.jpg

Pelagic Organism Decline



Larval Striped Bass

http://www.esf.edu/efb/limburg/research/FishyRes/Hudson/Hudson_research.html



Delta smelt

http://upload.wikimedia.org/wikipedia/commons/3/3a/Hypomesus_transpacificus.jpg



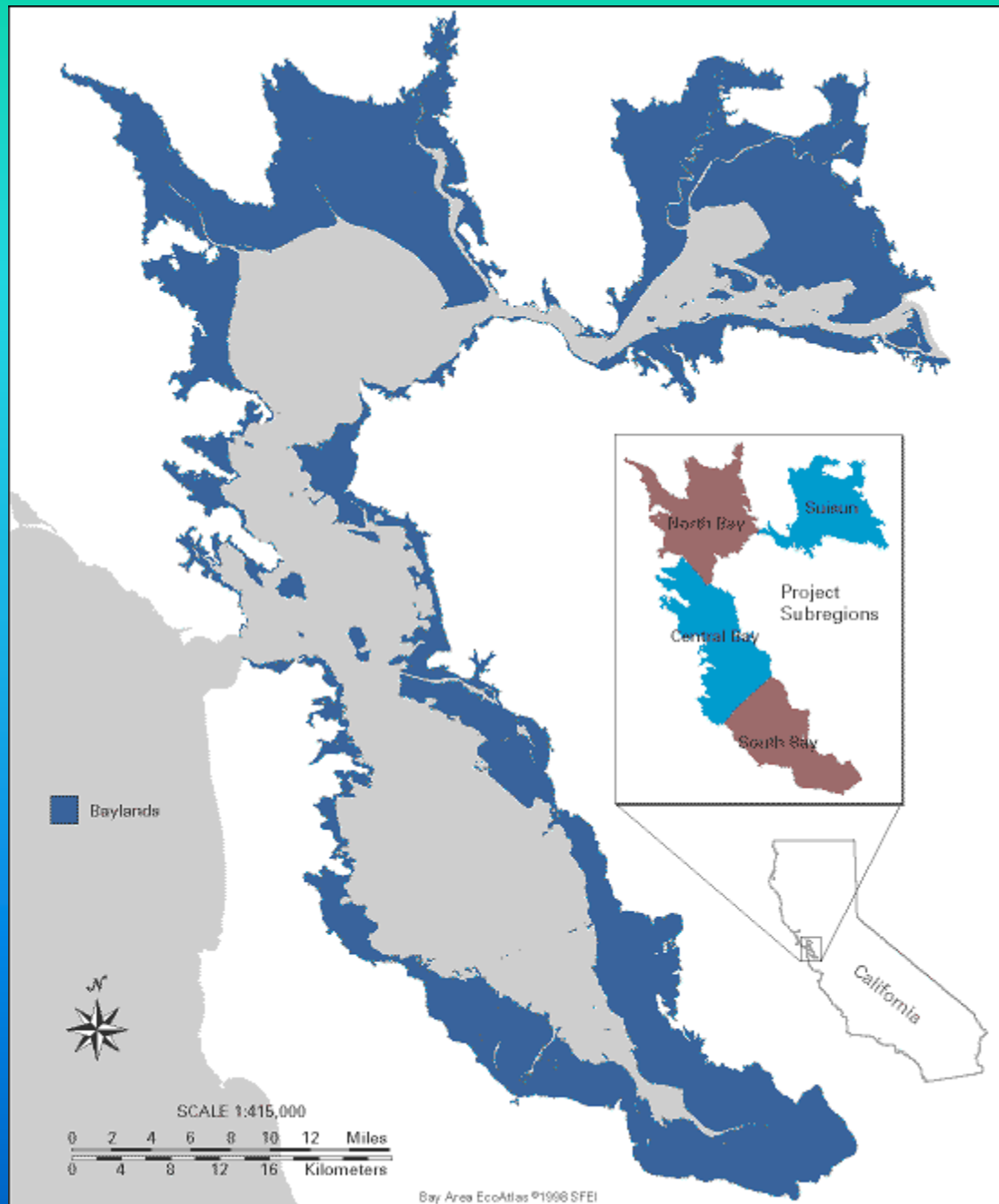
Longfin smelt

<http://www.voiceofsandiego.org/content/articles/2008/03/10/news/longfin031008-full.jpg>



Threadfin shad

<http://www.samford.edu/schools/artsci/biology/zoology/vertzoo-05s/pages/184.htm>



Suisun Bay

- Eurytemora affinis*
- Sinocalanus doerrii*

North Bay

- Eurytemora affinis*
- Sinocalanus doerrii*
- Acartia clausi*
- Acartia californiensis*
- Paracalanus parvus*

Central Bay

- Paracalanus parvus*

South Bay

- Acartia clausi*
- Acartia californiensis*
- Oithonadavisae*
- Eurytemora affinis*

Copepod Species	Origin	Date of Introduction (if applicable)
Acanthocyclops vernalis	Unknown	
Acartia clausi	Native	
Acartia californiensis	Native	
Acartiella sinensis	Exotic	1993
Diaptomus spp.	Native	
Eurytemora affinis	Native	
Limoithona sinensis	Exotic	1979
Limoithona tetraspina	Exotic	1993
Oithona davisae	Exotic	1963
Oithona similis	Exotic	
Paracalanus parvus	Unknown	
Pseudodiaptomus forbesi	Exotic	1987
Pseudodiaptomus marinus	Exotic	1986
Sinocalanus doerrii	Exotic	1978
Tortanus dextrilobatus	Exotic	1993

Ambler, Julie W., James E. Cloern, Anne Hutchinson. "Seasonal cycles of zooplankton from San Francisco Bay." Hydrobiologia 129 (1985): 177-197.

Avent, Sean R., Stephen M. Bollens, Wim Kimmerer, Jeff Cordell. "Copepods Invade the San Francisco Estuary." Ballast Exchange 2 (2000): 4-5.

Fuller, Pam. "Pseudodiaptomus marinus." USGS . 7 June 2005. 1 Apr. 2009 <<http://nas.er.usgs.gov/queries/CollectionInfo.asp?SpeciesID=177&>>.

Hooff, Rian C., Stephen M. Bollens. "Functional response and potential predatory impact of *Tortanus dextrilobatus*, a carnivorous copepod recently introduced to the San Francisco Estuary." Marine Ecology Progress Series. 277 (2004): 167-179.

Lee, Carol Enumi. "Rapid and repeated invasions of fresh water by the copepod *Eurytemora affinis*." Evolution. 53.5 (1999): 1423-1434.

Orsi, James J., Thomas E. Bowman, Dan C. Marelli, Anne Hutchinson. "Recent introduction of the planktonic calanoid copepod *Sinocalanus doerrii* (Centropagidae) from mainland China to the Sacramento-San Joaquin Estuary of California." Journal of Plankton Research. 5.3 (1983): 357-375.

Souza, Christine. "Delta smelt plan based on science." California Farm Bureau Federation. 2005. CFBF. 14 Jan. 2009 <<http://www.cfbf.com/agalert/AgAlertStory.cfm?ID=462&ck=51D92BE1C60D1DB1D2E5E7A07DA55B26>>

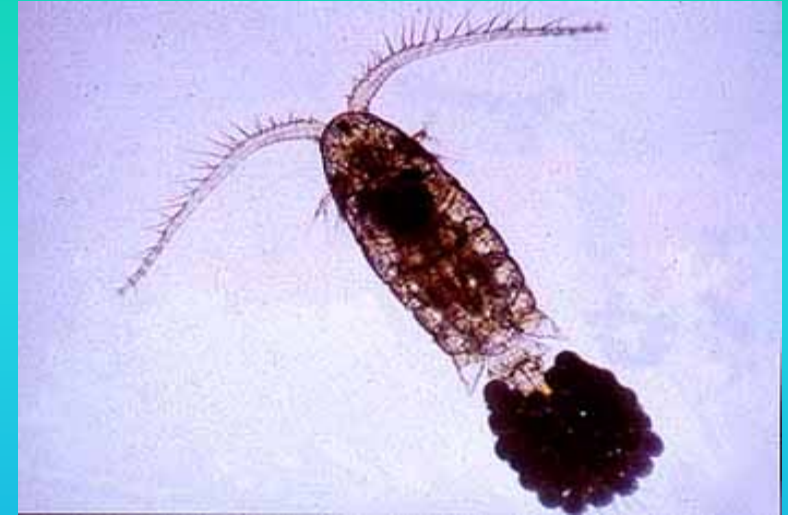


Sinocalanus doerrii



Pseudodiaptomus forbesi

<http://www.fish.washington.edu/people/cordell/gallery.html>



<http://www.zooplankton-online.net/gallery.html>

<http://life.bio.sunysb.edu/marinebio/plankton.html>

Copepod Species	Pesticide	LC or EC
<i>Acartia clausi</i>	Atrazine	LC50=7,945 ug/L
<i>Acartia clausi</i>	Cypermethrin	EC50= 1.10 ug/L
<i>Acartia tonsa</i>	Cypermethrin	LC50= 0.01 to 0.32 ug/L
<i>Acartia tonsa</i>	Diazinon	LC50=2.57 ug/L
Cyclopoida Copepods (unspecified)	Esfenvalerate	EC50=0.23 ug/L
<i>Eurytemora affinis</i>	Ammonia	Negative
<i>Eurytemora affinis</i>	Atrazine	LC50= 125 ug/L
<i>Eurytemora affinis</i>	Bifenthrin	LC50=7.75 ug/L
<i>Eurytemora affinis</i>	Diazinon	Negative
<i>Eurytemora affinis</i>	Diuron	Negative
<i>Eurytemora affinis</i>	HPAH	Negative
<i>Eurytemora affinis</i>	Lambda-Cyhalothrin	Negative
<i>Eurytemora affinis</i>	LPAH	Negative

Forget-Leray, Joelle, Isabelle Landriau, Christophe Minier, Francois Leboulenger. "Impact of endocrine toxicants on survival, development, and reproduction of the estuarine copepod *Eurytemora affinis* (Poppe)." Ecotoxicology and Environmental Safety. 60 (2005): 288-294.

Khattat, F., and S. Farley. "Acute Toxicity of Certain Pesticides to *Acartia tonsa*." U.S.EPA-OPP Registration Standard. 1976

Lozano, S.J., J.C. Brazner, M.L. Knuth, L.J. Heinis, K.W. Sargent, D.K. Tanner, L.E. Anderson, S.L. O'Halloran, S.L. Ber. "Effects, Persistence and Distribution of Esfenvalerate in Littoral Enclosures." Rep.No.DU E104/PPA 06/7592A, U.S.EPA, Duluth & Univ.of Wisconsin-Superior, Superior, WI :5 p. 1989.

Medina, M., C. Barata, T. Telfer, and D.J. Baird. "Age- and Sex-Related Variation in Sensitivity to the Pyrethroid Cypermethrin in the Marine Copepod *Acartia tonsa*." Archives of Environmental Contaminant Toxicology. 42.1 (2002): 17-22

Teh, Swee. "Toxic effects of surface water in the upper San Francisco Estuary on *Eurytemora affinis*." Personal Interview. 22 May 2009.

Thursby, G.B, D. Champlin, W. Berry. "Acute toxicity of Atrazine to copepods." Memo to D.J. Hansen, U.S. EPA, Narragansett, RI: 4 p. 1990.

Willis, K. J., N. Ling. "Toxicity of the aquaculture pesticide Cypermethrin to planktonic marine copepods." Aquaculture Res. 35.3 (2004): 263-270.

- Slide 1: http://images.google.com/imgres?imgurl=http://www.zooplankton-online.net/gallery_photos/eurytemweggs3%2520copy_thumb.jpg&imgrefurl=http://www.zooplankton-online.net/gallery.html&usg=__MdFj5ZVNOUr6-Ka20xTnrtOyhEM=&h=173&w=223&sz=17&hl=en&start=18&sig2=ayRslMZpNugkJvHPDsGAA&um=1&tbnid=euvJ60ueeEyB0M:&tbnh=83&tbnw=107&prev=/images%3Fq%3Dcoepod%2Beurytemora%26hl%3Den%26sa%3DG%26um%3D1&ei=UAvySdbyLIXstgPvpKHZCg
- Slide 3: (Nauplii) www.environmentalallevage.com/Copepods.htm
(Copepodite) www.stetson.edu
(Adult Copepods) www.edis.ifas.ufl.edu
- Slide 4: www.glerl.noaa.gov/seagrant/GLWL/Zooplankton
- Slide 5: http://images.google.com/imgres?imgurl=http://www.delta.dfg.ca.gov/baydelta/eurypic.gif&imgrefurl=http://www.delta.dfg.ca.gov/baydelta/monitoring/eurytem.asp&usg=__5bRuRglAVsSotB8Y_ZFs2nJxW-c=&h=311&w=186&sz=27&hl=en&start=9&sig2=8Vsj5-VGqRBtn2AicSDtKQ&um=1&tbnid=wbSXLH_8sFKYNM:&tbnh=117&tbnw=70&prev=/images%3Fq%3Dcoepod%2Beurytemora%26hl%3Den%26sa%3DG%26um%3D1&ei=UAvySdbyLIXstgPvpKHZCg
http://www.viewsfromscience.com/media/photos/Diatom_Composite_v2.jpg
- Ciliates: http://www.nsf.gov/od/lpa/news/03/images/fukami_morin1.jpg
- Dinoflagellate, http://www.geo.ucalgary.ca/~macrae/palynology/dinoflagellates/Spiniferites_half.gif
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<http://www.voiceofsandiego.org/content/articles/2008/03/10/news/longfin031008-full.jpg>
www.swr.nmfs.noaa.gov
- Slide 7: www.ceres.ca.gov
- Slide 9: <http://www.fish.washington.edu/people/cordell/images/Sinocal4.jpg>
- Slide 10: http://images.google.com/imgres?imgurl=http://www.zooplankton-online.net/gallery_photos/eurytemweggs3%2520copy_thumb.jpg&imgrefurl=http://www.zooplankton-online.net/gallery.html&usg=__MdFj5ZVNOUr6-Ka20xTnrtOyhEM=&h=173&w=223&sz=17&hl=en&start=18&sig2=ayRslMZpNugkJvHPDsGAA&um=1&tbnid=euvJ60ueeEyB0M:&tbnh=83&tbnw=107&prev=/images%3Fq%3Dcoepod%2Beurytemora%26hl%3Den%26sa%3DG%26um%3D1&ei=UAvySdbyLIXstgPvpKHZCg
<http://life.bio.sunysb.edu/marinebio/plankton.html>
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