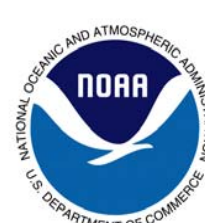


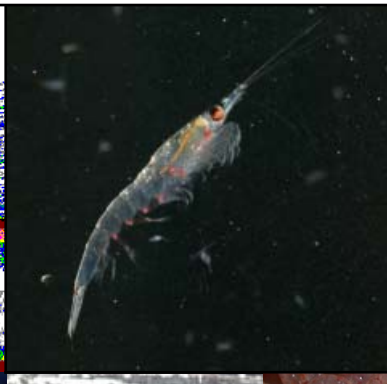
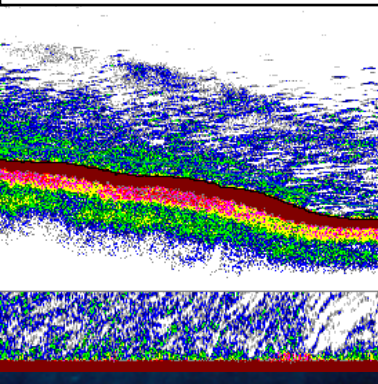


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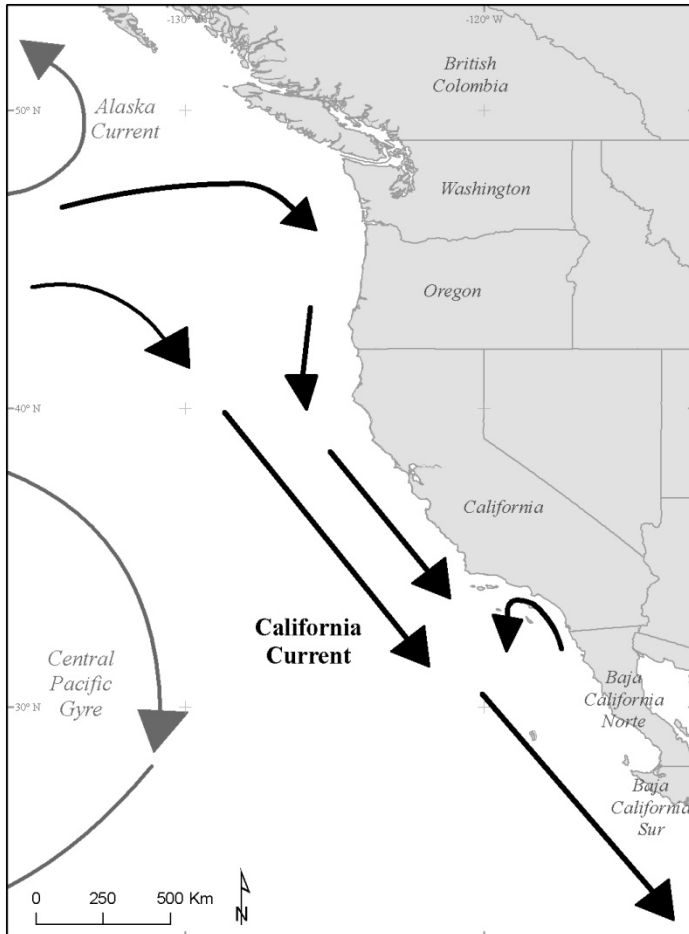
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Copepod assemblages as indicators of ocean conditions in Central California

Meredith L. Elliott, Jaime Jahncke, Moira Galbraith, and Dave Mackas
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Introduction



What is known about copepods in the California Current?

- Northern California Current

- Oregon (Peterson & Keister 2003)
- British Columbia (Mackas 1992, Mackas & Galbraith 2002)

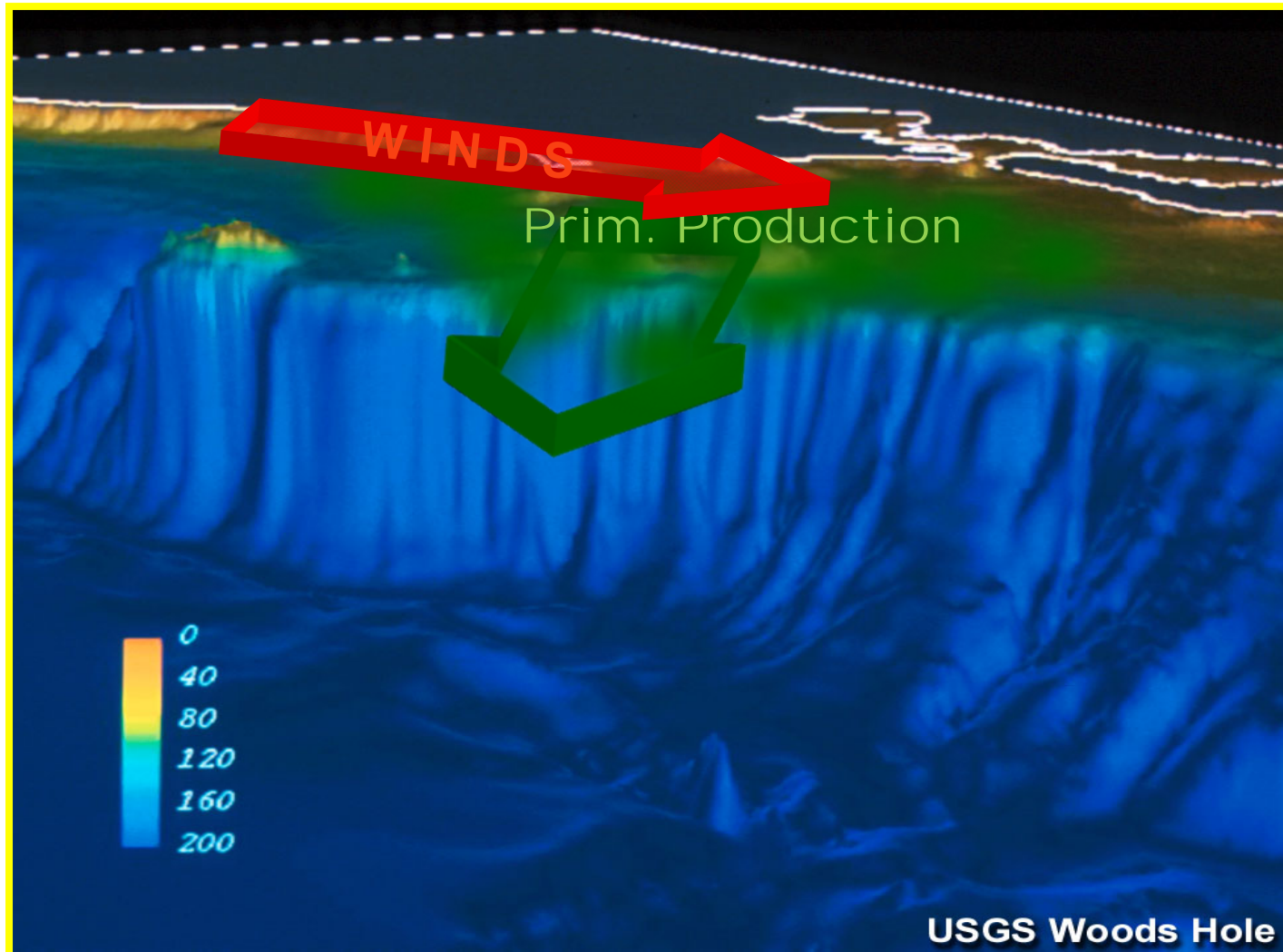
- Southern California Current

- Baja California (Jiménez-Pérez & Lavaniegos 2004, Hernández-Trujillo & Suárez-Morales 2002)

- Central California Current

- Monterey Bay (Hopcroft et al. 2002)
- ??? – data gap

Upwelling adds nutrients to the ocean



Hypothesis

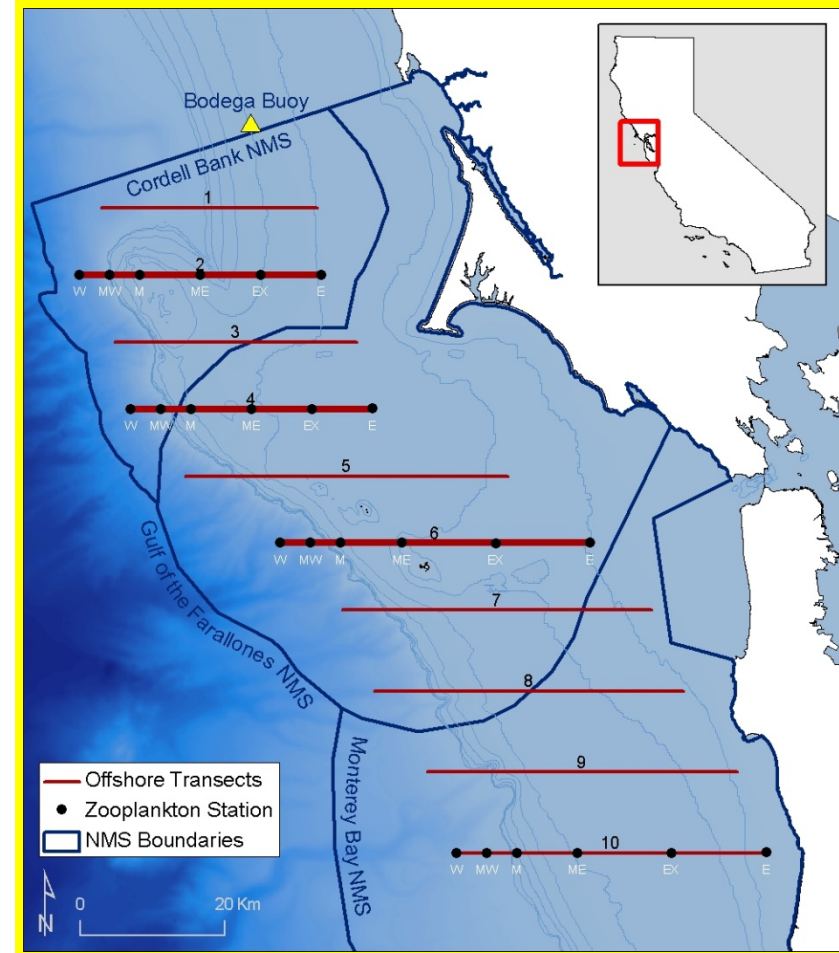
Copepod assemblages change in response to varying ocean conditions.

We predict that

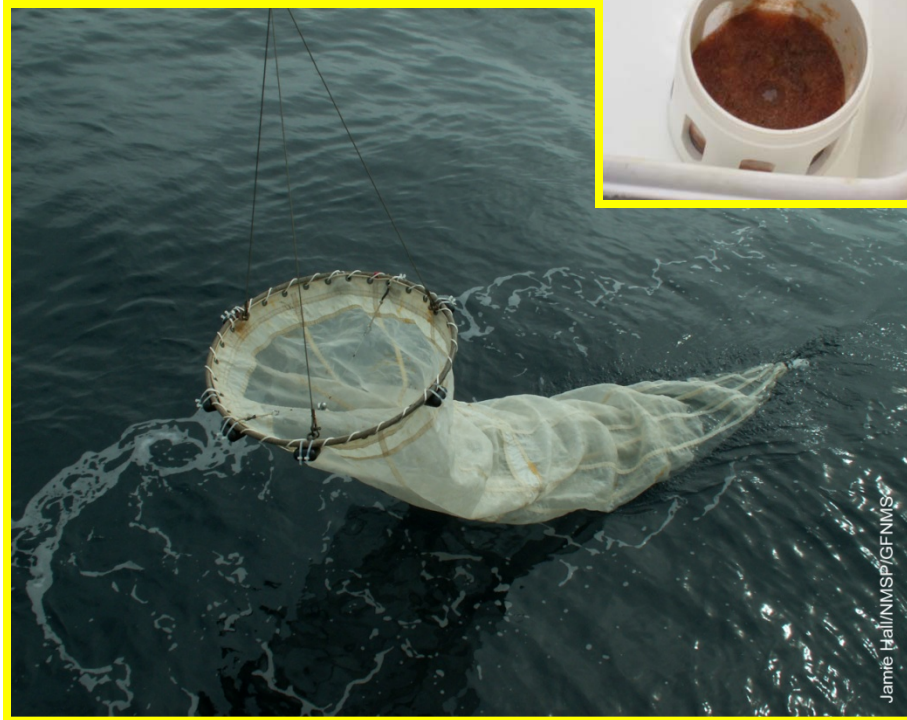
- Northern species will be more common in cold water years (La Niña).
- Southern species will be more common in warm water years (El Niño).

Methods

- At-sea surveys (2004 – 2008)
- Gulf of the Farallones NMS, Cordell Bank NMS
- Sampling on and off the continental shelf
- Lines 2, 4 & 6
- SST from Bodega buoy (NDBC Station 46013)



Zooplankton composition



- Hoop net with flowmeter (333 μm mesh)
- Upper 50 m
- All zooplankton identified to lowest taxonomic level (M. Galbraith)
- Abundance = $(\text{number of individuals}) \div (\text{volume of water sampled})$

Copepods and Climate

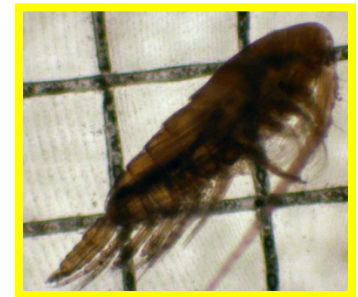
Copepod species

- **“Transition zone”** = common to the region
- **Boreal** = northern distribution
 - ➔ *More nutritious!*
- **Equatorial** = southern distribution

Climate indices

- **SOI** = Southern Oscillation Index
- **PDO** = Pacific Decadal Oscillation
- **NPGO** = North Pacific Gyre Oscillation

- **SST** = sea surface temperature



Correlation analysis

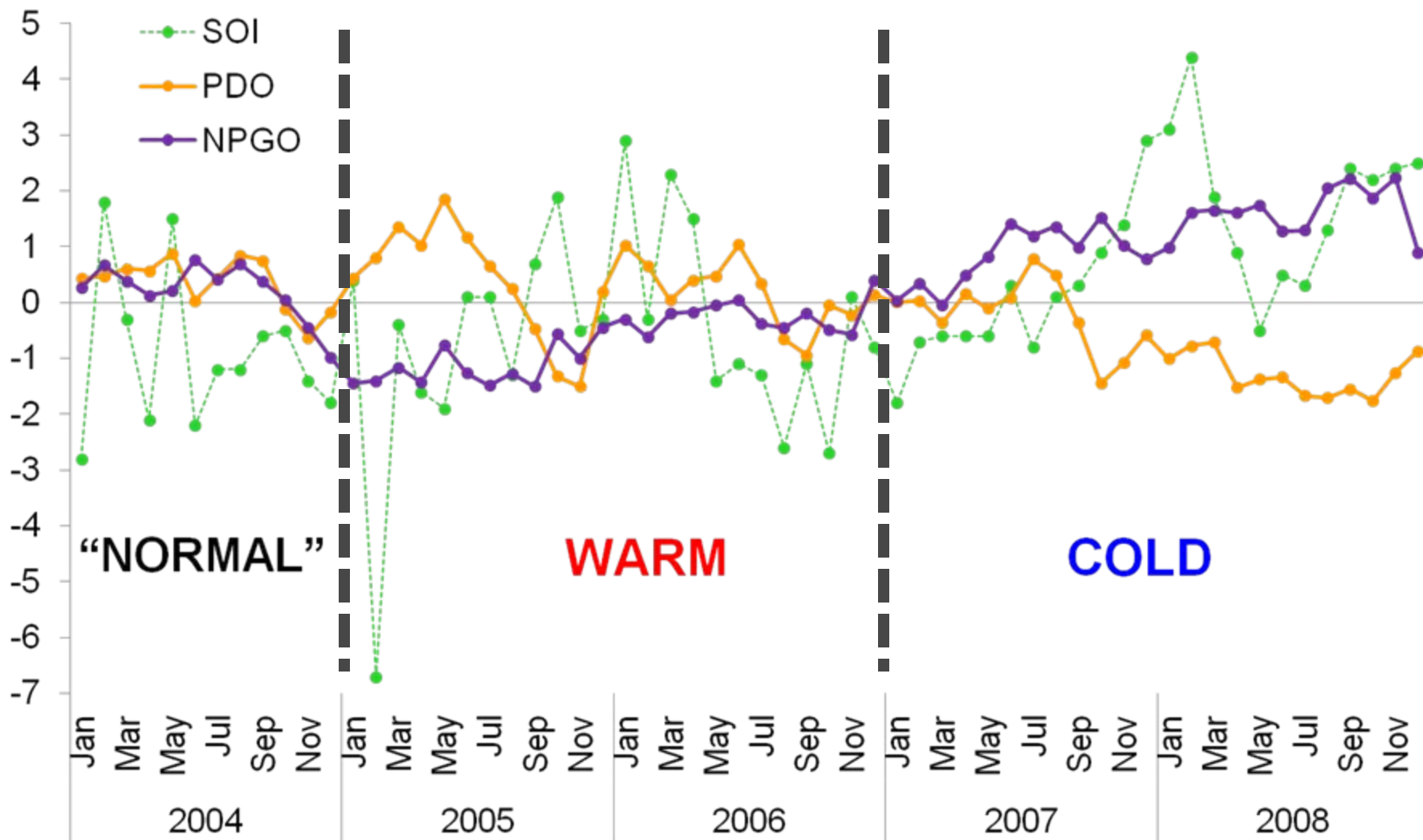
Spearman rank correlations

Monthly values of:

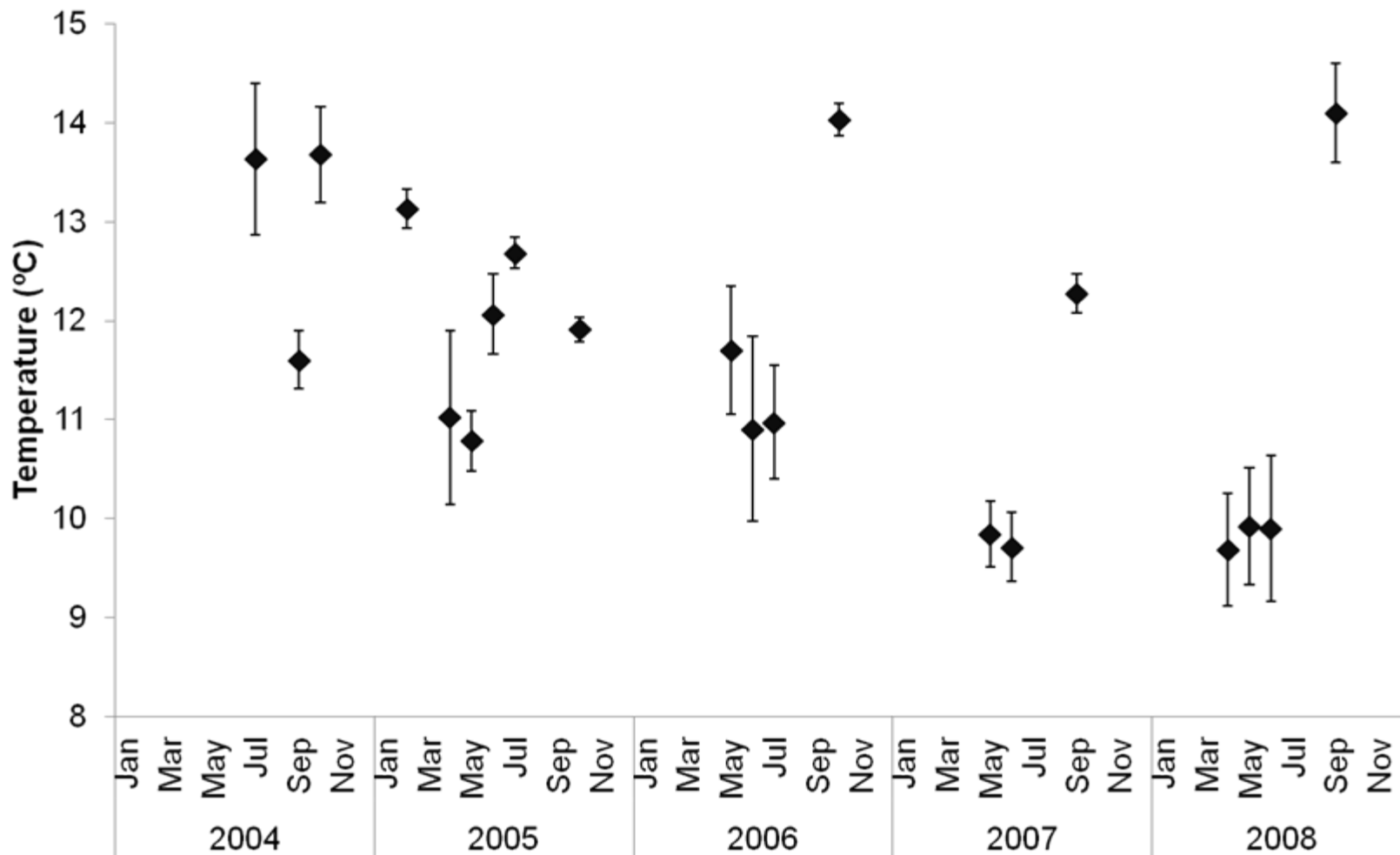
- Average copepod species abundance
- SOI
- PDO
- NPGO
- SST

Upwelling season, April – July (n=13)

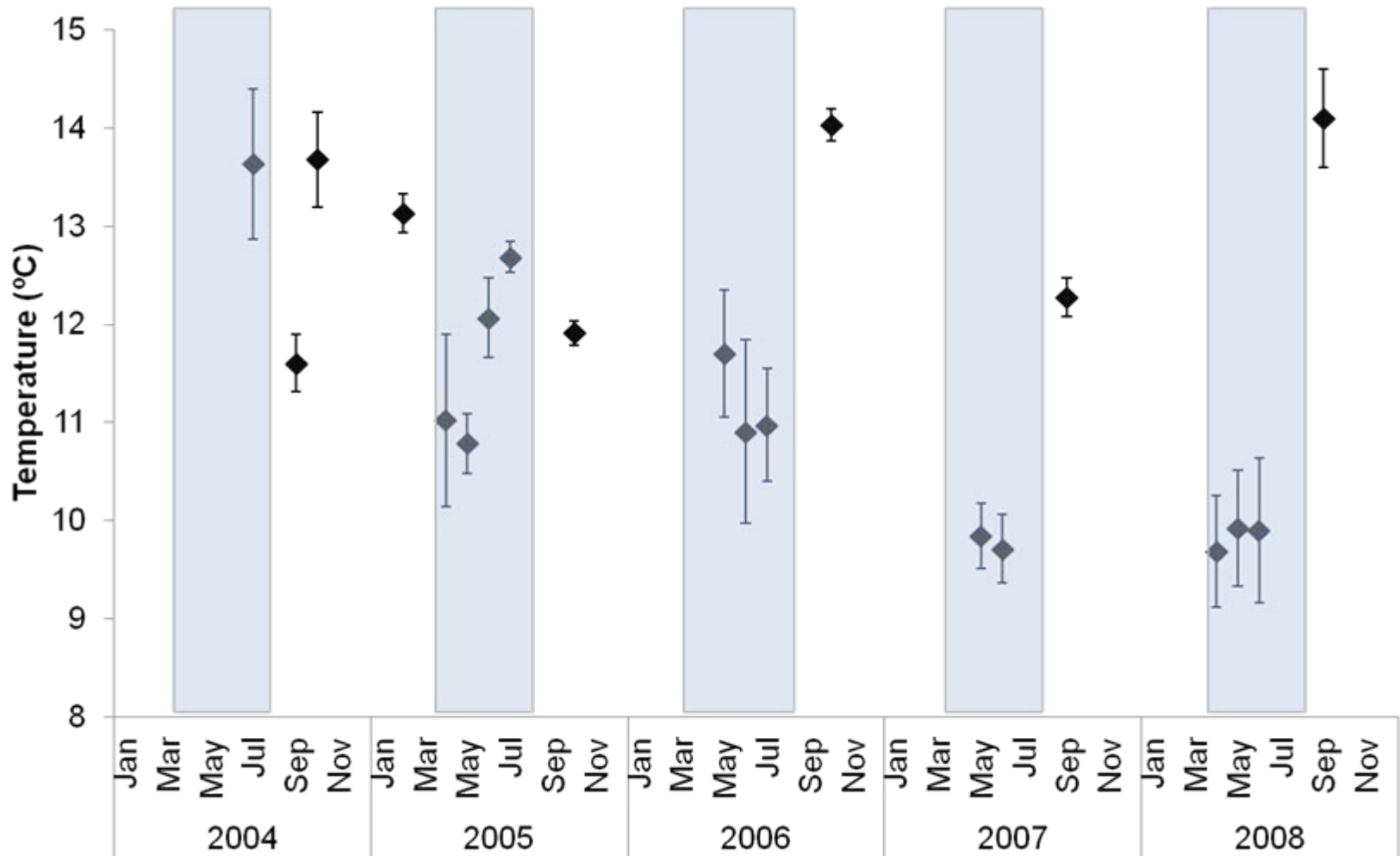
Climate variables



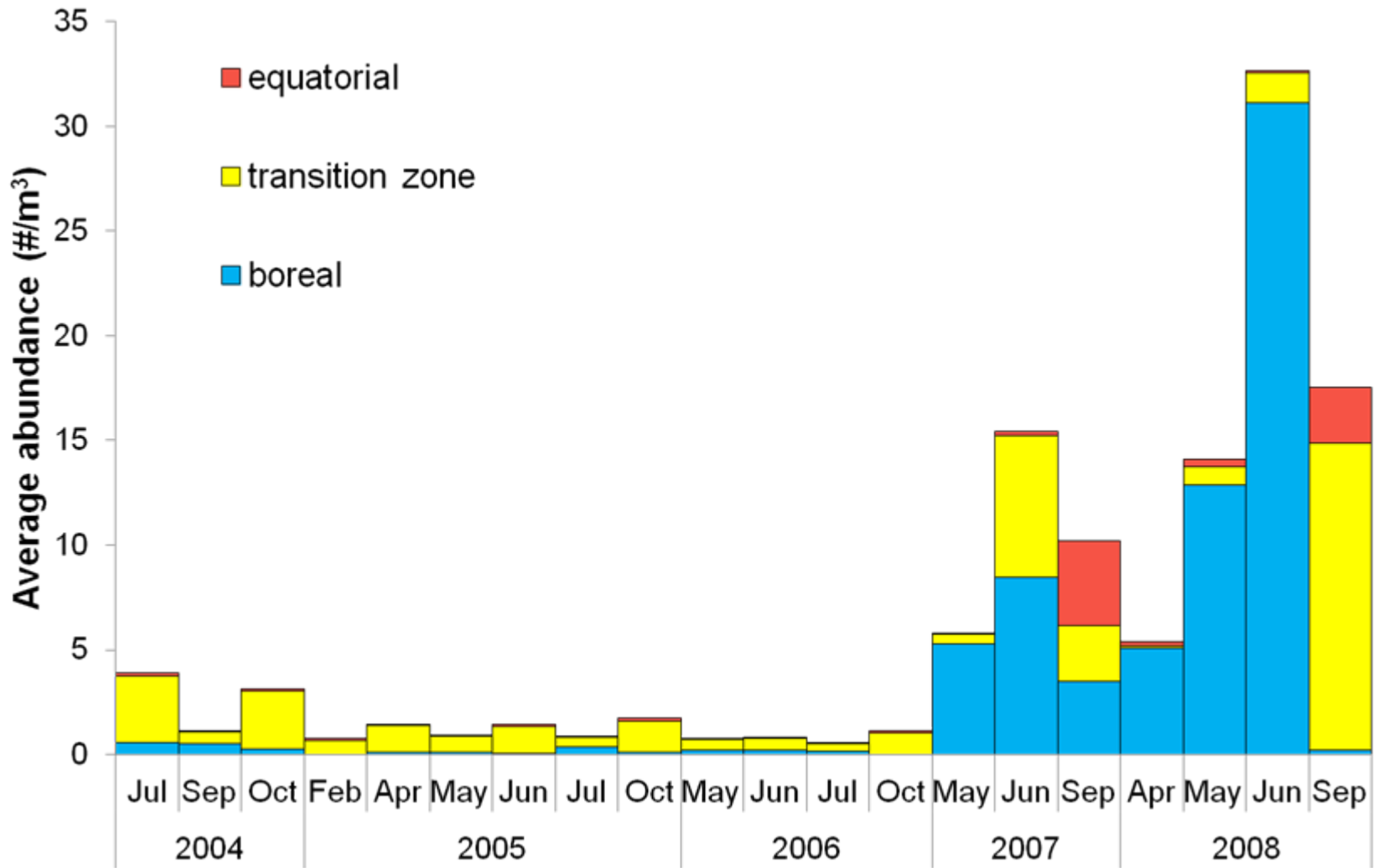
Sea surface temperature (SST)



Sea surface temperature (SST) *upwelling season*



Copepods



Climate indices vs. equatorial copepods *upwelling season (April – July)*

Spearman results (+/- rho), n=13

p < 0.05
0.05 < p < 0.1

Species	SOI	PDO	NPGO	SST
<i>Acartia danae</i>	+	+	+	-
<i>Aetideus bradyi</i>	-	+	-	+
<i>Corycaeus spp</i>	+	+	-	+
<i>Eucalanus hyalinus</i>	-	+	+	+
<i>Euchaeta media</i>	+	-	+	-
<i>Euchirella rostrata</i>	+	-	+	-
<i>Heterorhabdus papilliger</i>	-	+	-	+
<i>Lucicutia flavicornis</i>	-	-	+	-
<i>Pleuromamma abdominalis</i>	-	+	-	-
<i>Pleuromamma xiphias</i>	-	-	+	-
<i>Scolecithrix bradyi</i>	-	+	-	+
<i>Scolecithrix danae</i>	+	+	-	+

Climate indices vs. transition zone copepods *upwelling season (April – July)*

Spearman results (+/- rho), n=13

p < 0.05
0.05 < p < 0.1

Species	SOI	PDO	NPGO	SST
<i>Acartia tonsa</i>	-	+	-	+
<i>Calanus pacificus</i>	-	+	-	+
<i>Calocalanus tenuis</i>	+	-	+	-
<i>Candacia bipinnata</i>	+	+	-	+
<i>Centropages bradyi</i>	-	+	-	+
<i>Clausocalanus arcuicornis</i>	+	-	+	-
<i>Clausocalanus lividus</i>	-	+	-	+
<i>Clausocalanus mastigophorus</i>	.	-	+	-
<i>Clausocalanus parapergens</i>	+	+	-	-
<i>Corycaeus anglicus</i>	-	+	-	+
<i>Ctenocalanus vanus</i>	+	.	+	-
<i>Eucalanus californicus</i>	+	+	-	+
<i>Mesocalanus tenuicornis</i>	+	-	+	-
<i>Metridia pseudopacifica</i>	+	-	+	+
<i>Oithona atlantica</i>	+	-	+	-
<i>Oithona similis</i>	+	-	+	-
<i>Pleuromamma borealis</i>	-	+	-	.
<i>Rhincalanus nasutus</i>	-	+	-	+
<i>Scolecithricella ovata</i>	+	-	+	-

Climate indices vs. boreal copepods *upwelling season (April – July)*

Spearman results (+/- rho), n=13

p < 0.05
0.05 < p < 0.1

Species	SOI	PDO	NPGO	SST
<i>Acartia hudsonica</i>	+	-	+	-
<i>Acartia longiremis</i>	+	-	+	-
<i>Aetideus divergens</i>	+	-	+	-
<i>Calanus marshallae</i>	+	-	+	-
<i>Centropages abdominalis</i>	+	+	-	+
<i>Metridia pacifica</i>	-	-	+	+
<i>Neocalanus cristatus</i>	+	-	+	-
<i>Neocalanus plumchrus</i>	+	-	+	-
<i>Pseudocalanus mimus</i>	+	-	+	-
<i>Pseudocalanus minutus</i>	-	-	+	-
<i>Pseudocalanus moultoni</i>	-	-	+	+
<i>Scolecithricella minor</i>	+	-	+	-
<i>Tortanus discaudatus</i>	-	-	+	+

Conclusions

- More boreal and transition zone copepods in 2007-08.
- Abundance of boreal copepods during the upwelling season was greater during cold / productive water conditions.
 - ✓ What we predicted!
- Mixed results for equatorial and transition zone copepods.
- Abundance of equatorial species during the relaxation season was greater in fall 2007-08.
- Boreal copepod species may indicate good foraging conditions for marine organisms in central California.

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