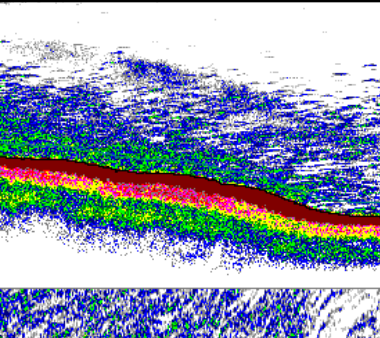
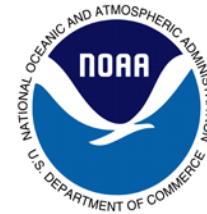


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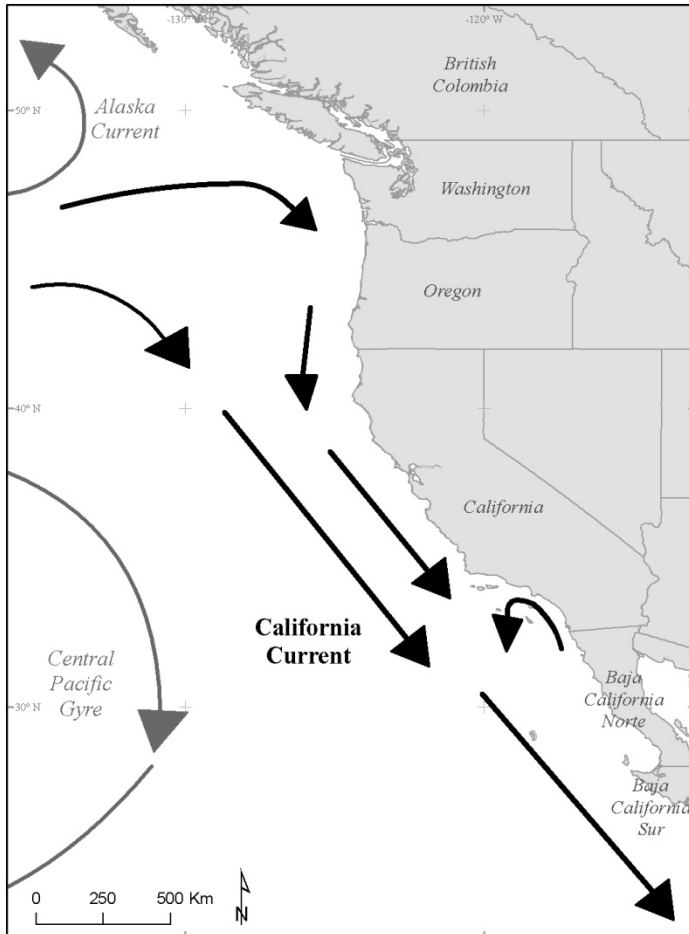
PRBO Conservation Science



Copepod assemblages as indicators of ocean conditions in Central California

Meredith L. Elliott, Jaime Jahncke, Moira Galbraith, and Dave Mackas
CBNMS Science Advisory Council Meeting
November 18, 2010

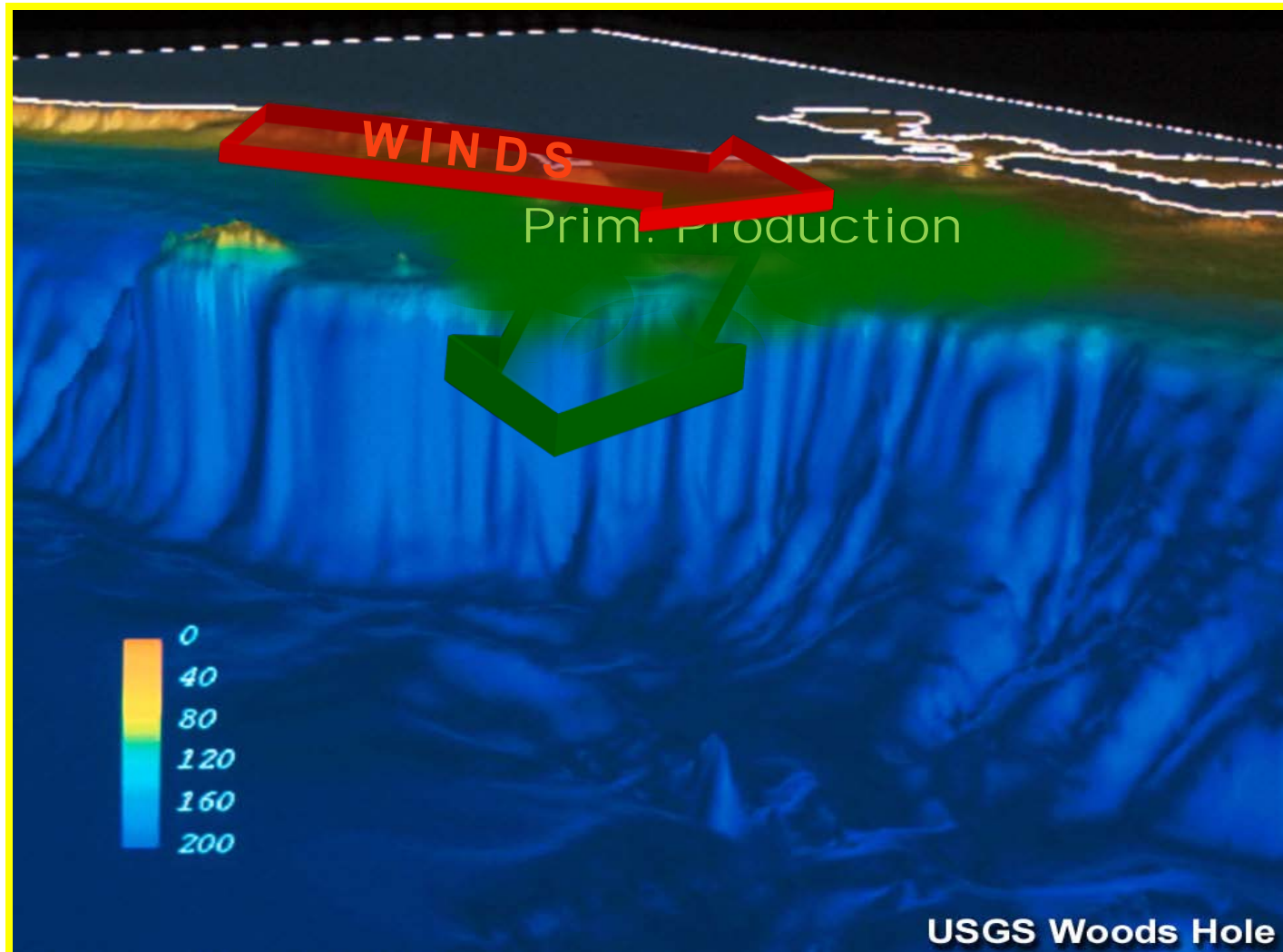
Introduction



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

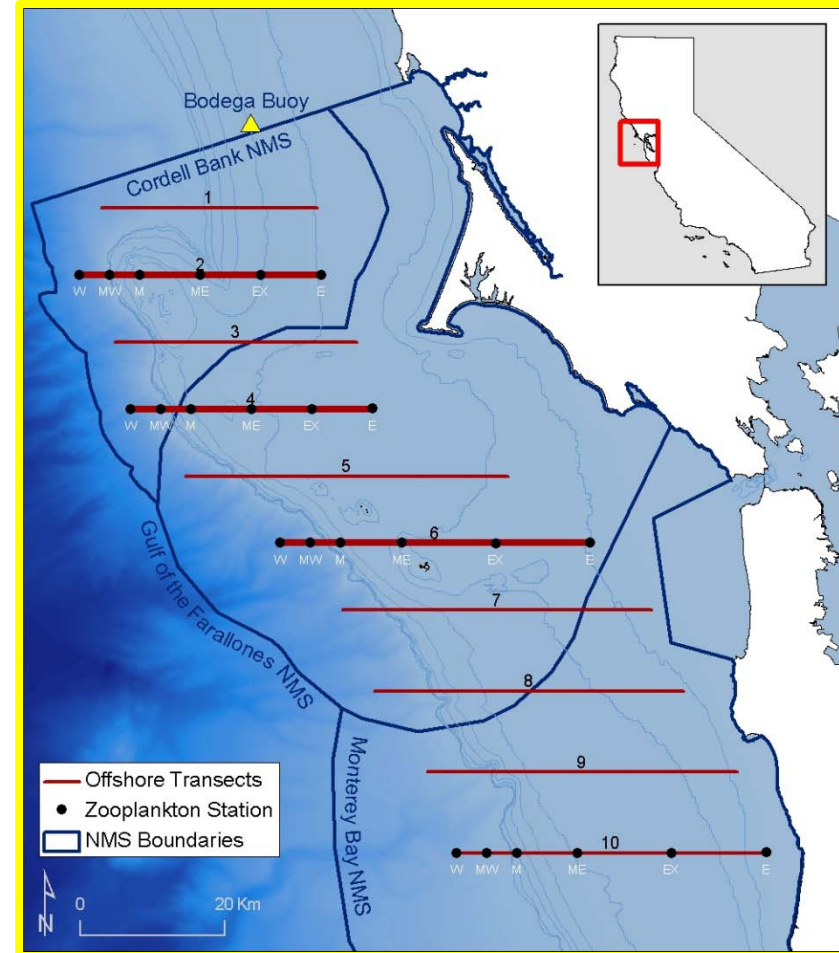
Copepod assemblages change in response to varying ocean conditions.

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

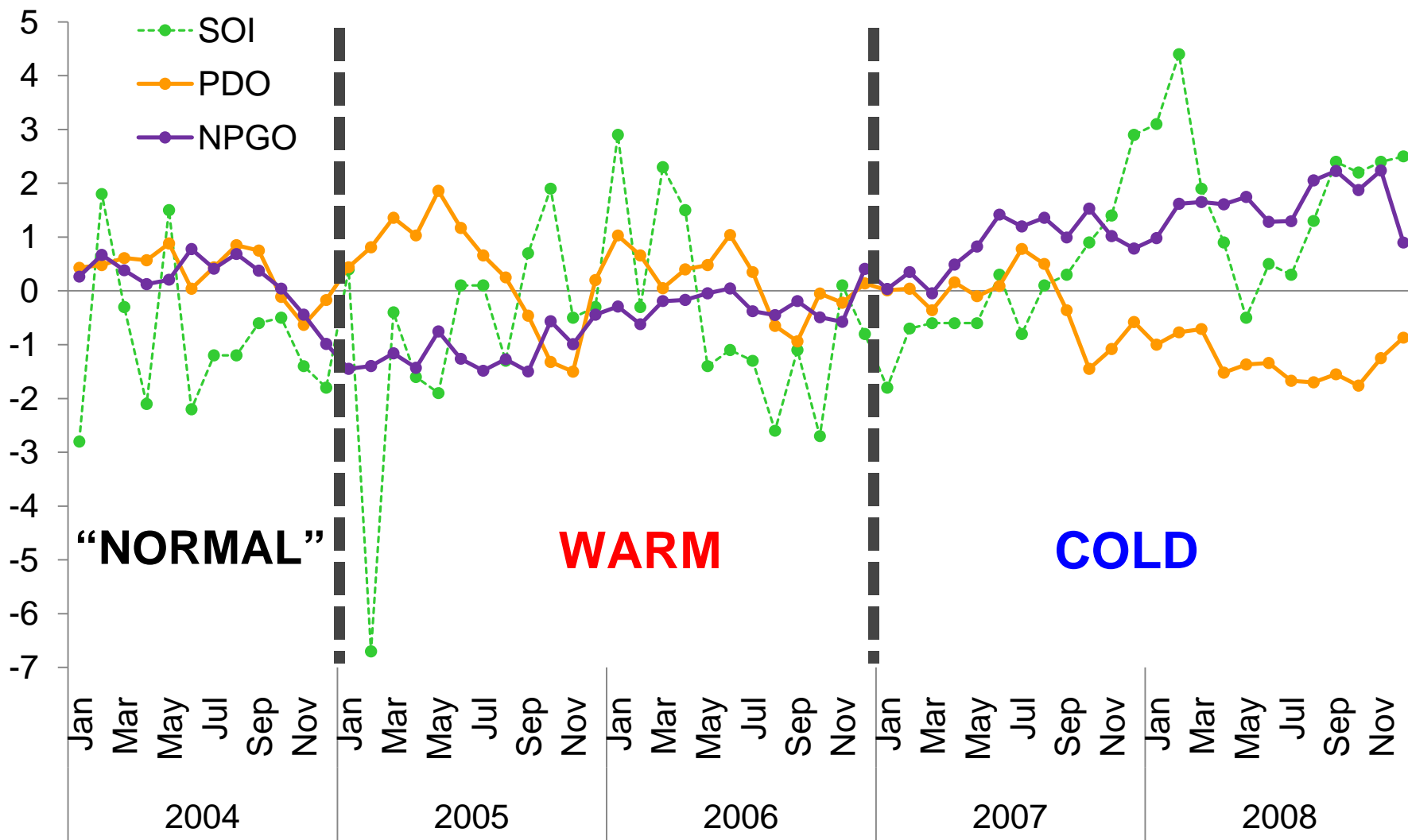
Spearman rank correlations

Monthly values of:

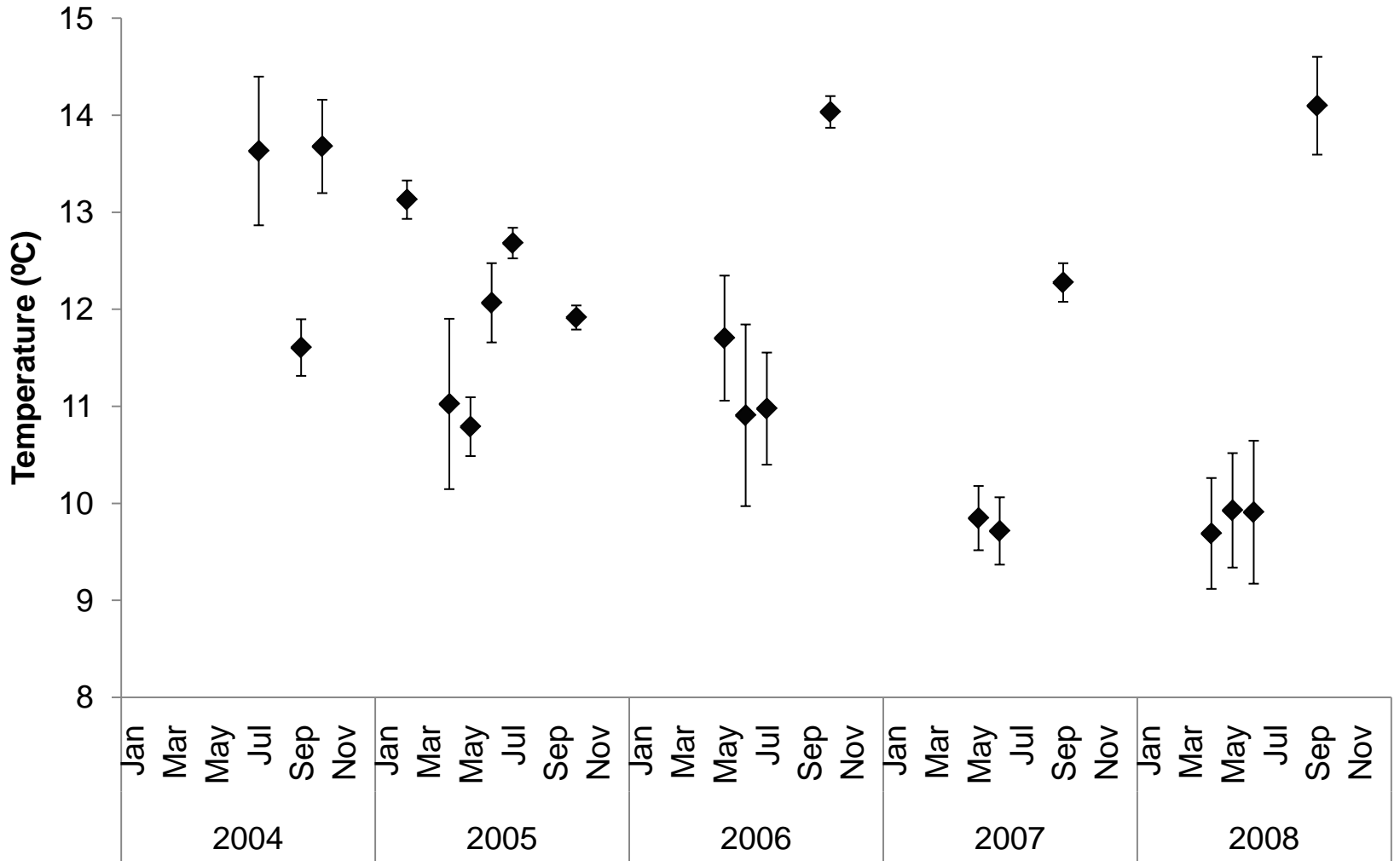
- Average copepod species abundance
- SOI
- PDO
- NPGO
- SST

Upwelling season, April – July (n=13)

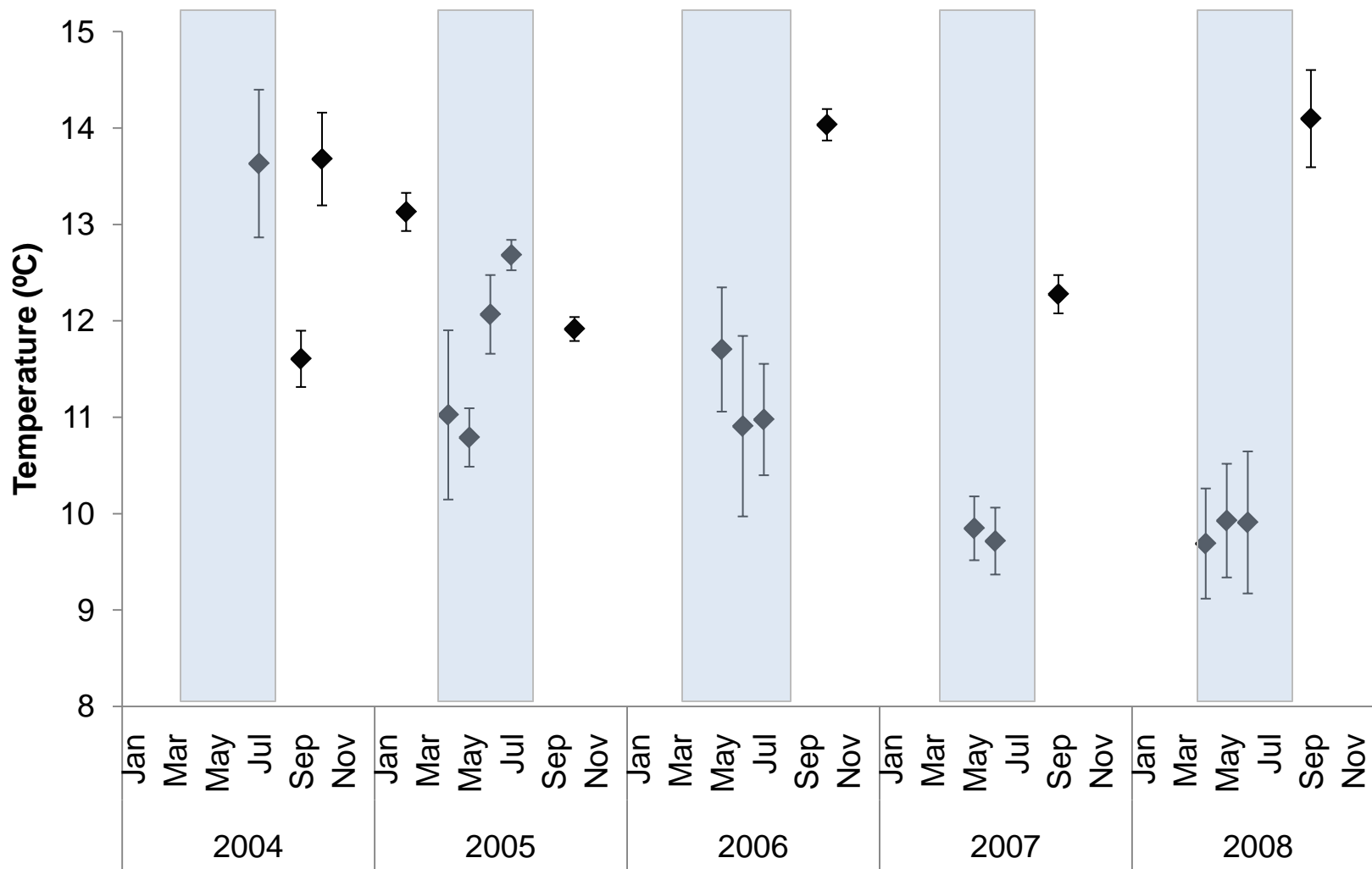
Climate variables



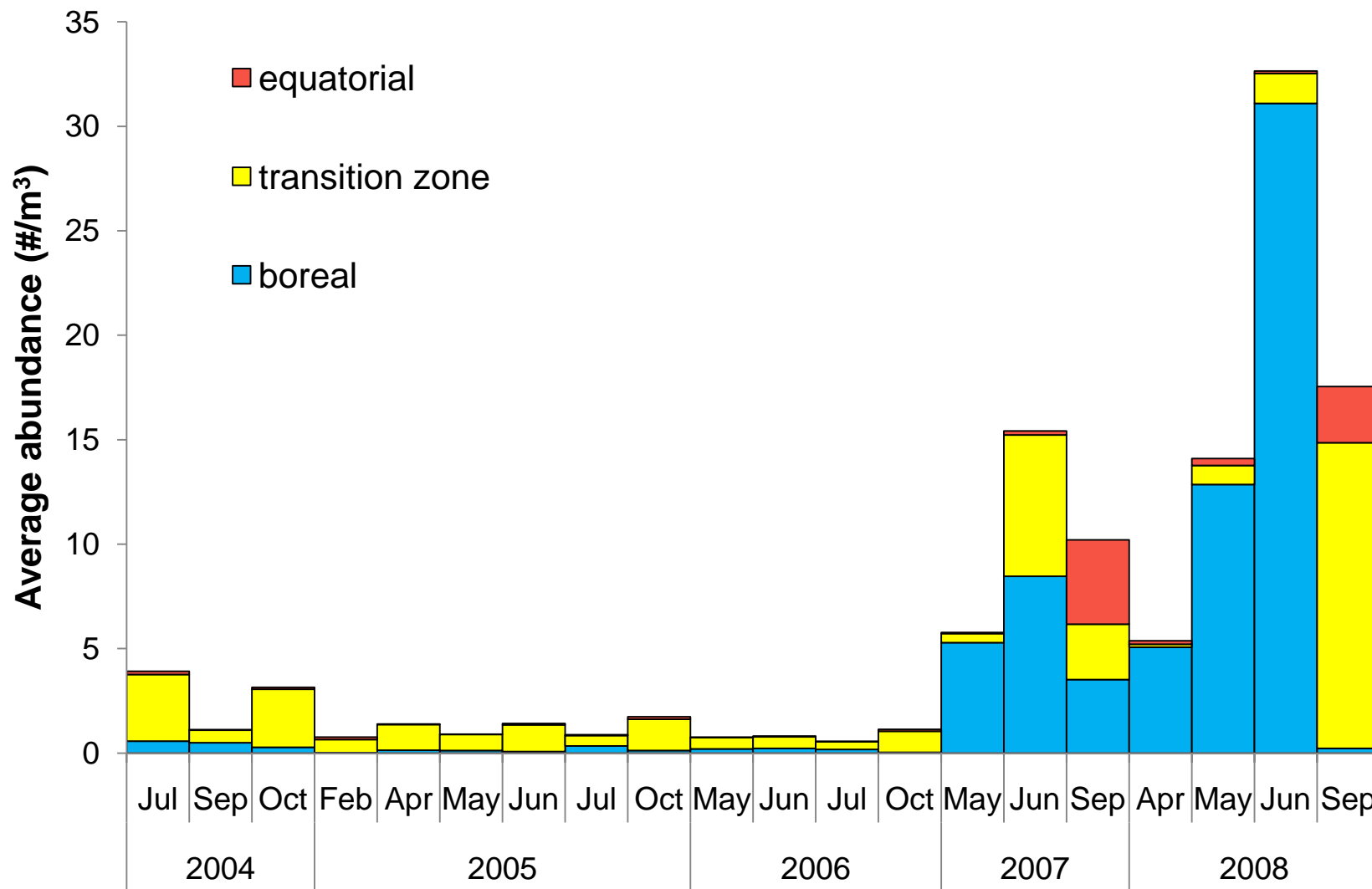
Sea surface temperature (SST)



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>	+	-	+	-

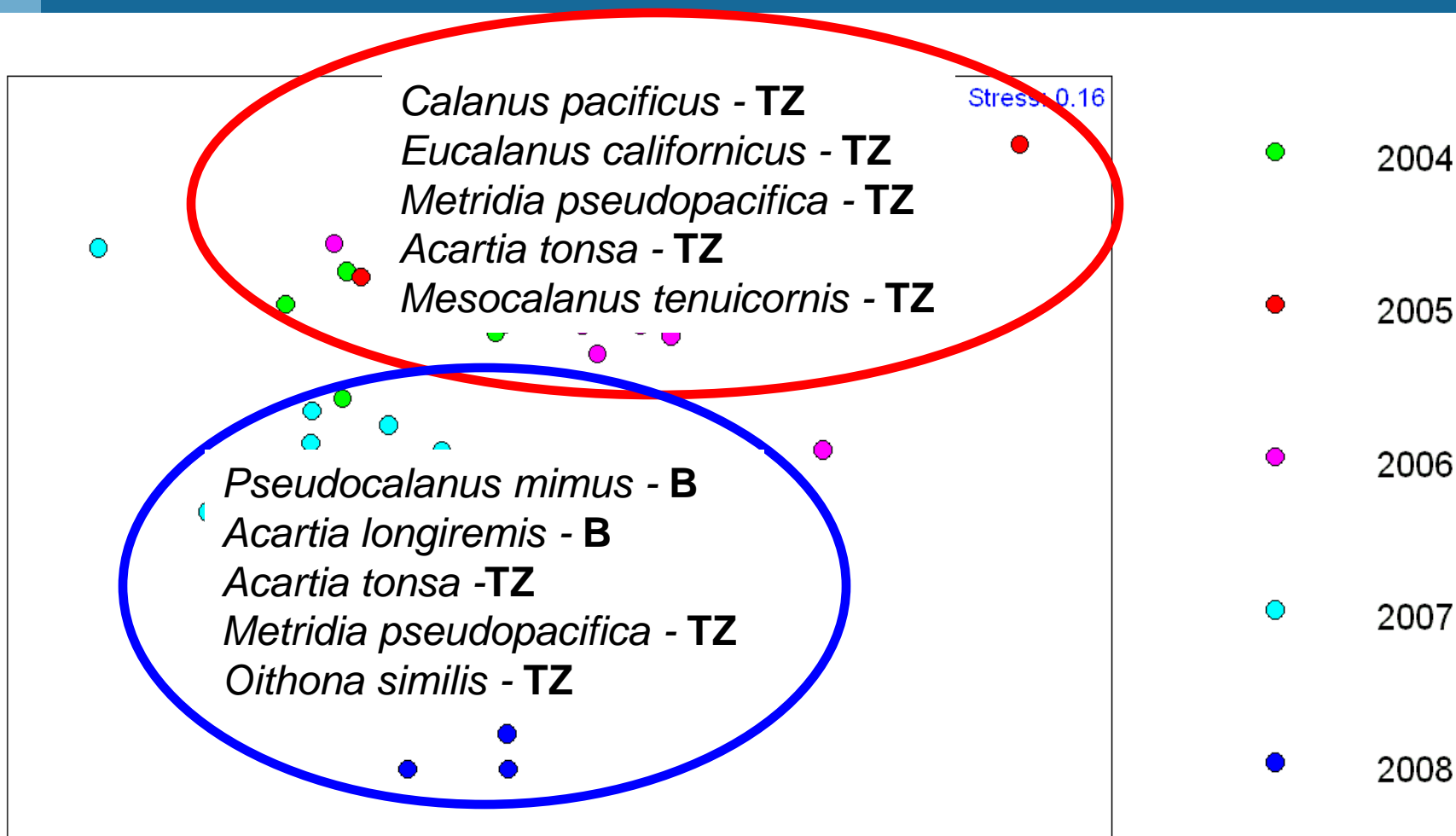
Climate indices vs. boreal copepods *upwelling season (April – July)*

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>	-	-	+	+

NMDS and SIMPER analysis



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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