Phenology of zooplankton species in the Oregon upwelling zone

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NH-Line Hydrographic and Zooplankton Time Series

Bi-weekly Sampling:

- 1969-1973
- 1983
- 1996 – present (Peterson et al.)

N = 363 visits to NH 05

= NOAA Weather Buoy
Seasonal Cycles in Northern California
Current Upwelling zone difficult to define clearly

• Regular and tidy seasonal cycle seen only in climatology

• Phytoplankton blooms can occur almost anytime between February and November depending on the weather.

• Recently there have been disruptions to the normal upwelling-production cycles...and there have been modifications to seasonal cycles

• Length of the upwelling season and the spring and fall transition dates of interest to salmon and seabirds and other LMRs... but how do we define these dates?
Four Topics

- The “seasonal cycle” is somewhat regular in phytoplankton, but not so for copepod biomass
- Winter bloom in February results in a burst in egg production by the euphausiid *Thysanoessa spinifera*
- Spring Transition
- Length of Upwelling Season
1. Seasonal Cycles

- 12-year climatology from biweekly sampling
- Seasonal cycles of nitrate, chlorophyll and copepods shows nice progression of peaks each with a one-month lag = the perfect world!
Copepod seasonal cycles

PDO negative (1999-2002)
PDO positive (97-98, 03-06, PDO neutral 2007

- 1996-1999 Below average
- 2000 Sept
- 2001 Aug
- 2002 June
- 2003 July
- 2004 May + Aug
- 2005 Very Low
- 2006 March + July
- 2007 High all year
2. Chlorophyll (SeaWiFS)

- 1998-2001 Spring Bloom in March-April
- 2002-2005 Spring Bloom in February
- 2006 no Feb bloom
- 2007 Feb bloom
Thysanoessa spinifera

- Peaks seen in 2001-2005 and 2007 in February
- No peaks until April/May in all other years
- Summer peaks in July-August (but September 2005)
- Implications: reach juvenile stage in 58 d in the lab (two months) and adult in 4 months. Thus the July spawning peaks likely are the product of females born in February
Euphausia pacifica

- Never spawn in winter
- Seldom spawn in spring
- Always spawn in July/August
Density of adult euphausiids

**E. pacifica** adults
- Abundant in Feb, April-May
- Low density June-July
- Higher Aug-Nov
- Dec inconclusive due to few samples

**T. spinifera** adults
- Never very abundant at NH25
- Highest abundance Aug-Sept, 3-4 animals m\(^{-3}\)
3. Seasonal cycles of winds and current structure off coastal Oregon:

- **Winter:**
  - Winds from the South
  - Downwelling
  - Poleward-flowing Davidson Current
  - Subtropical/southern species transported northward & onshore

- **Spring Transition in April/May**

- **Summer:**
  - Strong winds from the North
  - Coastal upwelling
  - Equatorward alongshore transport
  - Boreal/northern species transported southward

- **Fall Transition in October**
Cluster analysis

Results of processing of 363 samples

Two patterns:

- Clusters 1 and 2 capture seasonal variations.

- Clusters 3-5 capture warm vs. cold ocean and El Niño events.

Cluster analysis defines seasonal changes in community structure and can be used to define transition dates.

Following Peterson And Keister 2003
Summer (cold water) and Winter (warm water) Clusters

Apart from the 1998 El Niño, cluster fidelity was stunning!
### 4. Length of upwelling season and the PDO

<table>
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<th>Start Date</th>
<th>End Date</th>
<th>Length Days</th>
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**Length of upwelling season:**
- 174-231 d
- 64-134 d
PDO vs date of 'biological spring transition' (UPPER) and number of days that a cold water community persisted in a given year (LOWER)

- The more negative the PDO, the earlier the date of "biological spring"
  - 'Zero' point is day 10 April

- The more negative the PDO the longer a cold water community persists.
  - 64-154 d when PDO positive
  - 174-231 d when PDO negative
Logerwell vs Peterson Transition Dates

http://www.cbr.washington.edu/data/trans_data.html

\[ y = 166.3 \left(1 - \exp^{-0.0077 \cdot x}\right), \quad R^2 = 0.39 \]

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Mean = 128 (Copepods) v 103 (Sea Level)
Coho salmon survival vs. spring transition Dates

- Early transition yields better coho survival
- “Biological” transition dates better correlated with coho than “physical” transition dates
Length of upwelling season vs. coho survival

- Length of upwelling season equal fall date - spring date

- Longer upwelling seasons (as indexed by summer copepod communities) result in higher coho salmon survival
Summary

- Seasonal cycles of copepods highly variable among years;
- Late winter spawning by the euphausiid *Thysanoessa spinifera* appears to be dependent on presence of a late-winter phytoplankton bloom; perhaps results in more/less juveniles and adults 4-6 months later (this is a new discovery -- we have not looked at stock-recruit relationships);
- A highly variable date of spring transition should affect reproduction and feeding by those animals that depend upon production resulting from the spring transition;
- Length of the upwelling season is a new variable that we may want to examine more closely
Acknowledgements

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  - since 1997: Leah Feinberg, Tracy Shaw, Julie Keister, Jen Menkel, Rian Hooff, Jay Peterson, Jesse Lamb, Karen Hunter
  - in the 1970s and 1980s: Peter Rothlisberg, Greg Lough, Charlie Miller, Hal Batchelder
PDO vs Copepod Community Structure

- As with SST and copepod species richness, copepod community structure also tracks the PDO.
Community Structure vs. temperature and salinity measured at Newport (depth of 50 m) at the same time the plankton tows were taken

- Correlations are better with T than S
- Perhaps salinity will correlate better with the NPGO as shown for the Southern California current?
NPGO vs Salinity

Salinity vs NPGO

R-sq = 0.07, p = 0.006

North Pacific Gyre Oscillation

Salinity Anomaly 50 m depth
Northern Copepods and Ordination Scores highly correlated

\[ y = -0.1234 - 0.5176 X \]

R-sq = 0.78
NOAA Buoy 46050 20 miles offshore

- Climatology: upwelling intense on day 202 (21 July)
- Past three years:

![Graphs showing temperature anomalies for 2005, 2006, and 2007](image-url)
NH05 Copepod Biomass Timeseries
(Monthly Averaged)

Copepod Biomass (mg C/m³)

YEAR

Summer Average

YEAR