The euphausiids *Euphausia pacifica* and *Thysanoessa spinifera* in the coastal upwelling zone off the Oregon Coast, USA

C. Tracy Shaw, Leah R. Feinberg, Jennifer Fisher, and William T. Peterson
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**The Euphausiids vs The Warm Blob**

*Euphausia pacifica*  
*Thysanoessa spinifera*

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Target Species

- Generally found at and beyond the shelf break (>200 m depth)
- Intense period of spawning during summer upwelling season
- Present in cool & warm ocean conditions

- Generally found on the shelf (<200 m depth)
- Spawn before & during upwelling, no intense period
- Prefer cooler ocean conditions

Euphausia pacifica

Thysanoessa spinifera
Time series off Newport, OR (NH line)

- Sampled twice per month 1996-2013; ~monthly 2014-present
- Night bongo net samples for adult euphausiids from 2001-present (15 years so far)
- Data for this presentation:
  - no 2014
  - 2015 (Jan-July)
- Station distance offshore & depth
  - NH05 – 8 km, depth 60m
  - NH10 – 16 km, depth 80m
  - NH15 – 25 km, depth 90m
  - NH20 – 32 km, depth 140m
  - NH25 – 40 km, depth 296m

😊
Ocean Temperature 1996-2015
SST Anomaly at NOAA Buoy 46050

buoy adrift, no data
(Tracy moves to RI)

30-Sept
25m tow - no adults 100m tow - lots
Avoiding warm surface water?

31 Aug 2015

14 Sep 2014 (1600 GMT)

+5

(6h)

-2

14 Sep 2014 (1000 GMT)
<table>
<thead>
<tr>
<th>Year</th>
<th>Spring transition (ST)</th>
<th>Fall transition (FT)</th>
<th>Upwelling (months)</th>
<th>Cold water copepods (months)</th>
<th>PDO phase</th>
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<tbody>
<tr>
<td>1998</td>
<td>El Niño</td>
<td></td>
<td></td>
<td></td>
<td>Warm</td>
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<tr>
<td>2001</td>
<td>1-May</td>
<td>7-Oct</td>
<td>5.3</td>
<td>7.7</td>
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<td>2002</td>
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<td>6.7</td>
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<td>21-Aug</td>
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<td>2006</td>
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<td>7.9</td>
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<tr>
<td>2009</td>
<td>14-May</td>
<td>11-Oct</td>
<td>5.0</td>
<td>9</td>
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<td>14-Sep</td>
<td>3.2</td>
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<td>2011</td>
<td>16-Apr</td>
<td>11-Sep</td>
<td>4.9</td>
<td>6.3</td>
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<tr>
<td>2012</td>
<td>4-May</td>
<td>7-Oct</td>
<td>5.2</td>
<td>5.8</td>
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<tr>
<td>2013</td>
<td>7-Apr</td>
<td>22-Aug</td>
<td>4.6</td>
<td>5.9</td>
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<tr>
<td>2014</td>
<td>10-May</td>
<td>20-Sep</td>
<td>4.4</td>
<td>3.5</td>
<td>Warm</td>
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<tr>
<td>2015</td>
<td>11-Apr</td>
<td>1-Oct</td>
<td>5.8</td>
<td>NA</td>
<td>Warm</td>
</tr>
</tbody>
</table>

2015 comparison:
Duration of upwelling similar to other years
No biological transition

(www.damp.coas.oregonstate.edu/windstress/allyears.html)
Warm blob & euphausiids

• Will there be any euphausiids?
• Rare or new species of euphausiids?
  – Many “warm blob” copepod species rare or never before seen in our study area
• Will euphausiidi densities decrease?
• Will they be spawning?
• Will they be smaller in length?
• Change in biomass?
• Changes in cross-shelf distribution?
2015 SST & Krill Data

SST at Buoy 46050 (Stonewall Bank, Oregon)

- **21-Jan**: No adult euphausiids
- **6-Jan**: Few spawning *E. pacifica*
- **18-Feb**: Spawning *E. pacifica*
- **26-Mar**: Few spawning *E. pacifica*
- **7-Apr**: Buoy adrift – no data
- **19-May**: Phyto bloom – all *E. pacifica* spawning
- **26-July**: Thick doliolids, no adult euphausiids
- **26-Mar**: Thick doliolids, no adult euphausiids
E. pacifica adults

![Graph showing the average total length (mm) of E. pacifica adults from 1998 to 2013. The graph includes data points for each year and a trend line. The x-axis represents the months, and the y-axis represents the average total length. The graph shows a general increase in average length from 1998 to 2002, followed by a decrease until 2013. The years 1998-2013 are indicated by a black line.](image-url)
T. spinifera adults

No adults 1998 or 2015

2015 adults = Ø (Jan-July)

1998 (Ø adults)

1999
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2015

Avg Monthly Length
Density & Species Composition (adults)

- *E. pacifica* density very low 1998 (El Niño)
- *E. pacifica* densities high 1999-2006, lower 2007-present; 2015 similar to 2013
- *T. spinifera* densities low during warm PDO years, variable in cool years; no adults in 2015
- *T. inspinata* is the only other species we see regularly; 2015 densities similar to other years
E. pacifica biomass

avg biomass (mg C m⁻³)

Adults

Juveniles
E. pacifica biomass

1998 & 2015: similar responses to strong warming events
T. spinifera biomass

- 2015 biomass: similar to 2004 and 2007
- Only year with no adults
Cross-shelf pattern for 2001-2013 similar for cool & warm PDO

*E. pacifica* might even like a little warming

Drastically lower biomass in 2015 suggests that they would **not** like a lot of warming
**T. spinifera** cross-shelf biomass cool vs. warm PDO + 2015

- Biomass offshore essentially the same for cool and warm PDO
- 2015 similar offshore biomass, but only juveniles and only from one sample (July)
- Biomass inshore higher during cool conditions (max of 5 mgC m$^{-3}$ = 5 large adults)
Warm blob answers?

• **Euphausia pacifica**
  – Present? Yes
  – Spawning? Yes
  – Smaller lengths? Yes
  – Lower density? Yes
  – Lower biomass? Yes
  – Cross-shelf?
    • No *E. pacifica* biomass inshore, offshore biomass much lower than other years

• **Thysanoessa spinifera**
  – Adults absent Jan-July
  – Cross-shelf
    • No biomass inshore where it is usually highest; offshore biomass similar to other years but juveniles only

• **Rare or new species of euphausiids?** No
Implications

- Euphausiids off the Oregon Coast are adapted to cooler ocean conditions
  - *E. pacifica* does well with warm or cool PDO but not with more extreme temperatures; response to 2015 similar to 1998
  - *T. spinifera* adults completely absent during warm conditions in 2015, also absent during 1998 El Niño

- Potential effects of warming on spawning and abundance
  - Spawning may be reduced in warm conditions due to fewer adults, smaller adults, lack of phytoplankton blooms, increase in gelatinous zooplankton
  - Both species have a lifespan of about two years. Warm conditions lasting two or more years in a row could result in reduced euphausiid abundance (migration and reduced reproduction).
  - Reduced euphausiid abundance may impact higher trophic levels, including commercial fish and seabirds

- How would we interpret data from 2015 if we didn’t have this long-term time series data set for context?
Acknowledgements

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• My boss at the University of Rhode Island (Dr. Brad Seibel) for sending me to this meeting to talk about data that has nothing to do with my current job

• My former boss (Bill Peterson) just for being Bill
Euphausiids Live Work Protocol

Protocols for Measuring Molting Rate and Egg Production of Live Euphausiids

Celebrating 10 years on the PICES website! (2005-2015)

Available on the PICES website! (www.pices.int) under the “Projects” heading

• Everything you always wanted to know about working with live euphausiids!

Courtesy of the Peterson Lab at Hatfield Marine Science Center, Newport, Oregon, USA

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