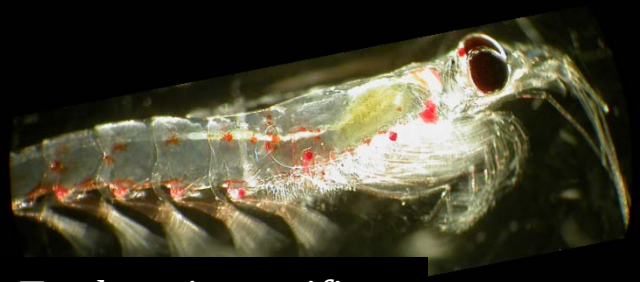
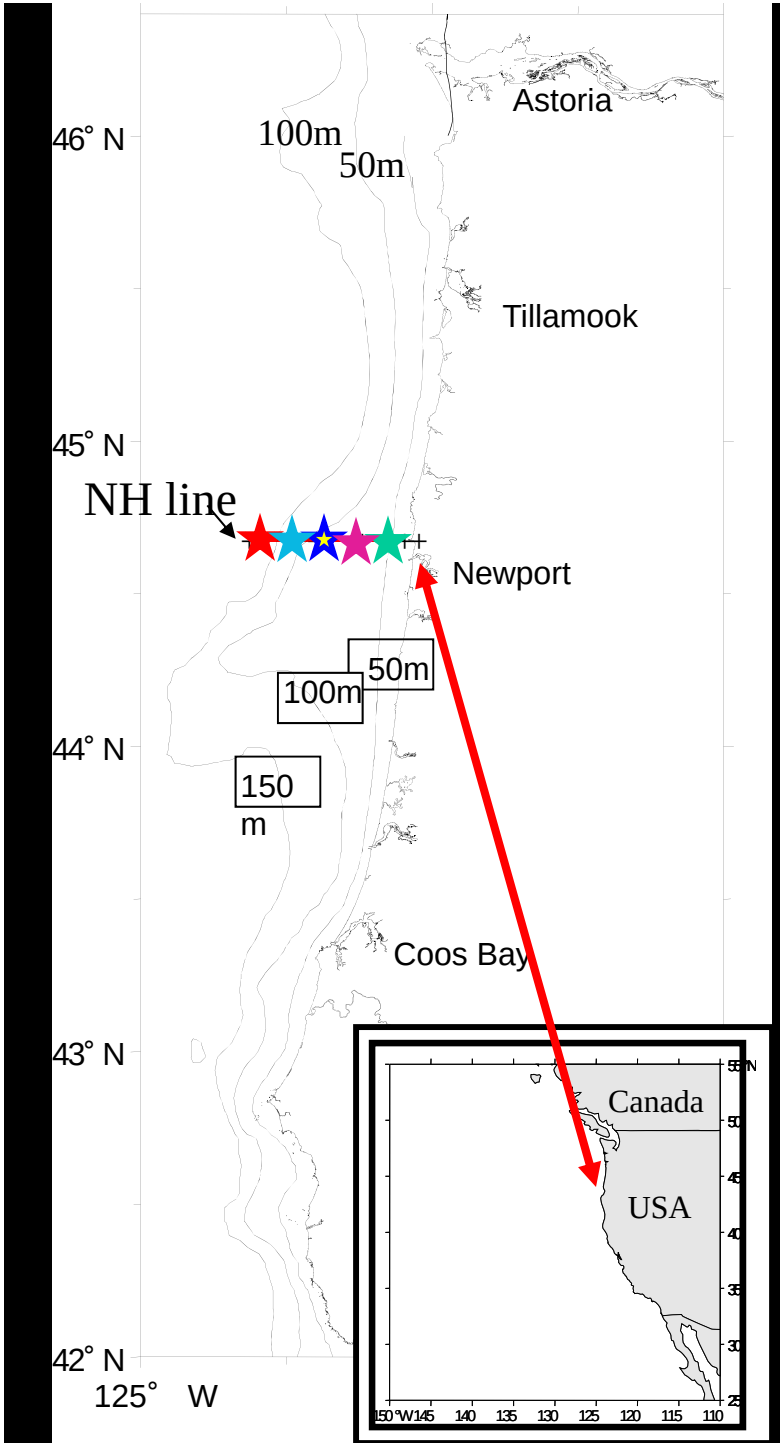
A tale of two krill: who, when, where, and how many? The euphausiids *Euphausia pacifica* and *Thysanoessa spinifera* in the coastal upwelling zone off the Oregon Coast, USA



Euphausia pacifica

Thysanoessa spinifera

C. Tracy Shaw, Leah R. Feinberg, Jennifer Fisher, and William T. Peterson



Time series off Newport, OR (NH line)

- Sampled twice per month starting in 1996
- Adult euphausiids sampled with night bongo tows from 2001-present (13 years so far)
- Environmental conditions
  - warm & cold PDO phases
  - timing of spring and fall transition dates
  - duration of upwelling
  - 2002 – anomalously cold due to intrusion of subarctic water

Target Species

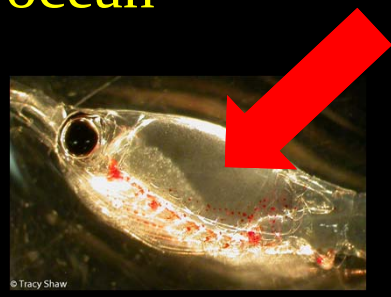
Adults of both species ~1-2 mg C per individual

Euphausia pacifica

- 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
- Do not store lipids

Thysanoessa spinifera

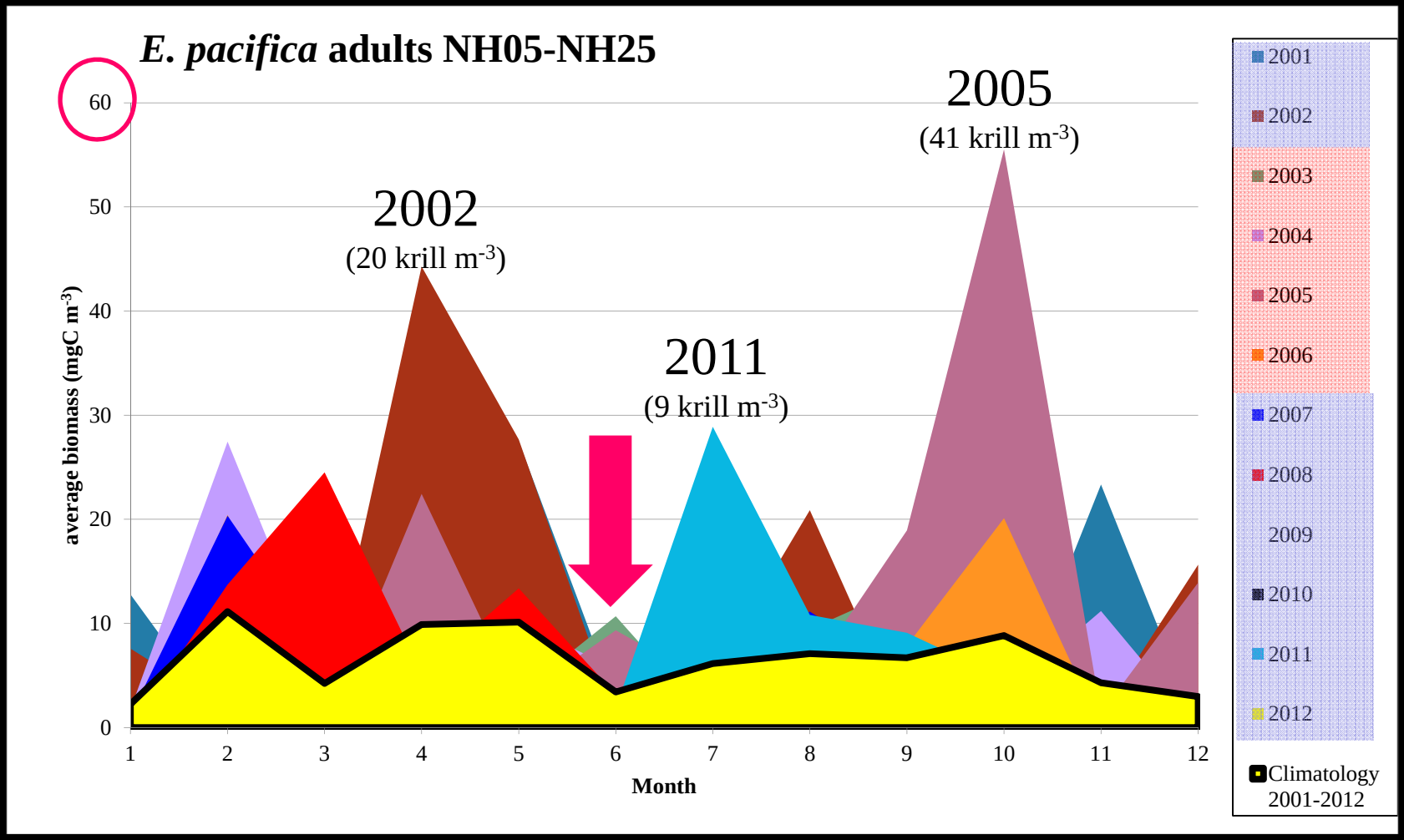
- Generally found on the shelf (<200 m depth)
- Spawn before & during upwelling, no intense period
- Prefer cooler ocean conditions
- Store lipids



Ocean Conditions

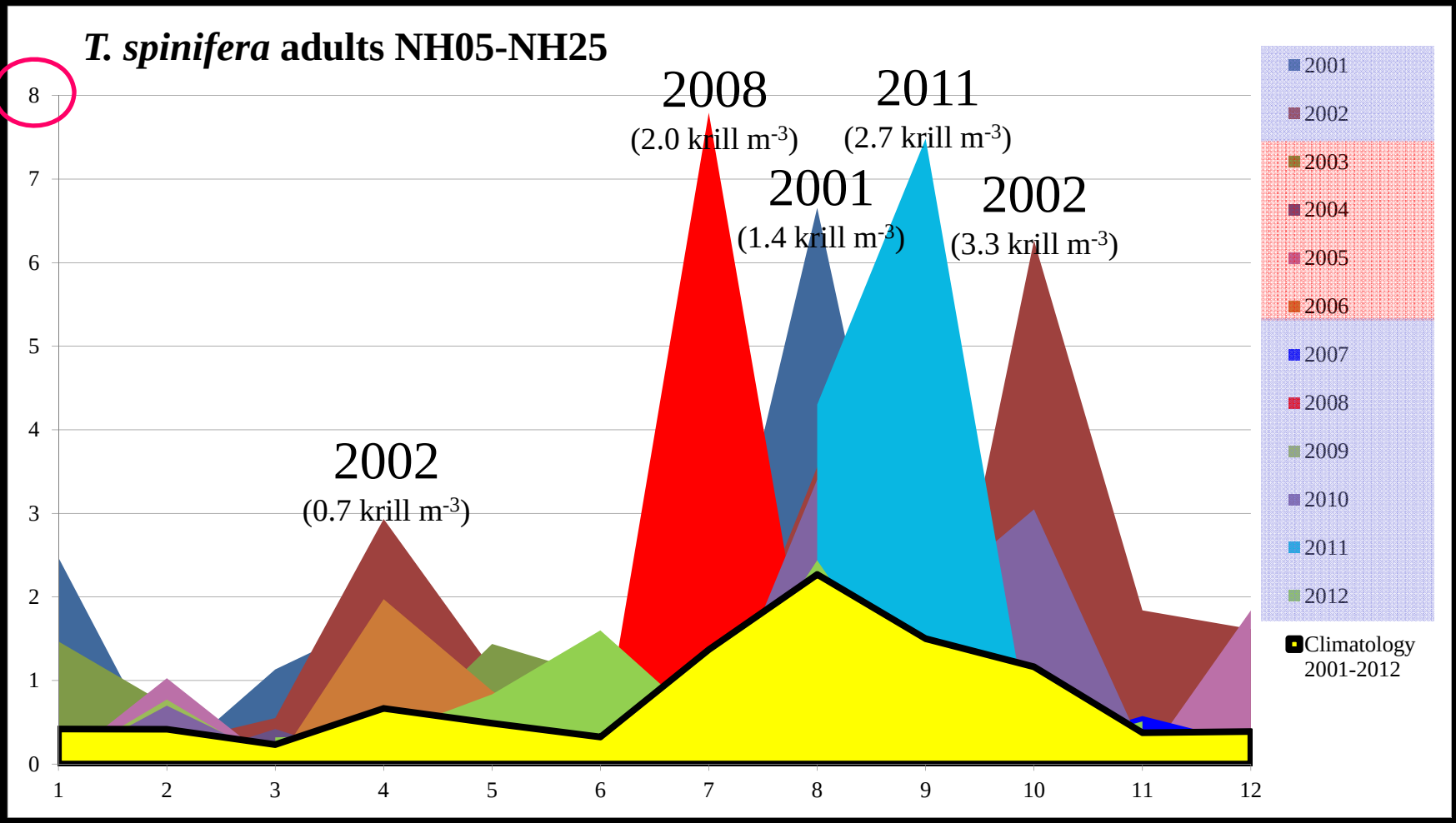
Year	Spring transition (ST)	Fall transition (FT)	Duration of upwelling (mo)	Ocean temp. (PDO phase)
2001	2-Mar	12-Nov	8.5	Cool
2002	21-Mar	6-Nov	7.7	Cool
2003	22-Apr	15-Oct	5.9	Warm
2004	20-Apr	7-Nov	6.7	Warm
2005	25-May	29-Sep	4.2	Warm
2006	22-Apr	31-Oct	6.4	Warm
2007	15-Mar	27-Sep	6.5	Cool
2008	30-Mar	24-Oct	6.9	Cool
2009	8-Mar	6-Oct	7.1	Cool
2010	9-Apr	13-Oct	6.2	Cool
2011	31-Mar	16-Sept	5.6	Cool
2012	3-May	11-Oct	5.4	Cool

Biomass – *E. pacifica* adults



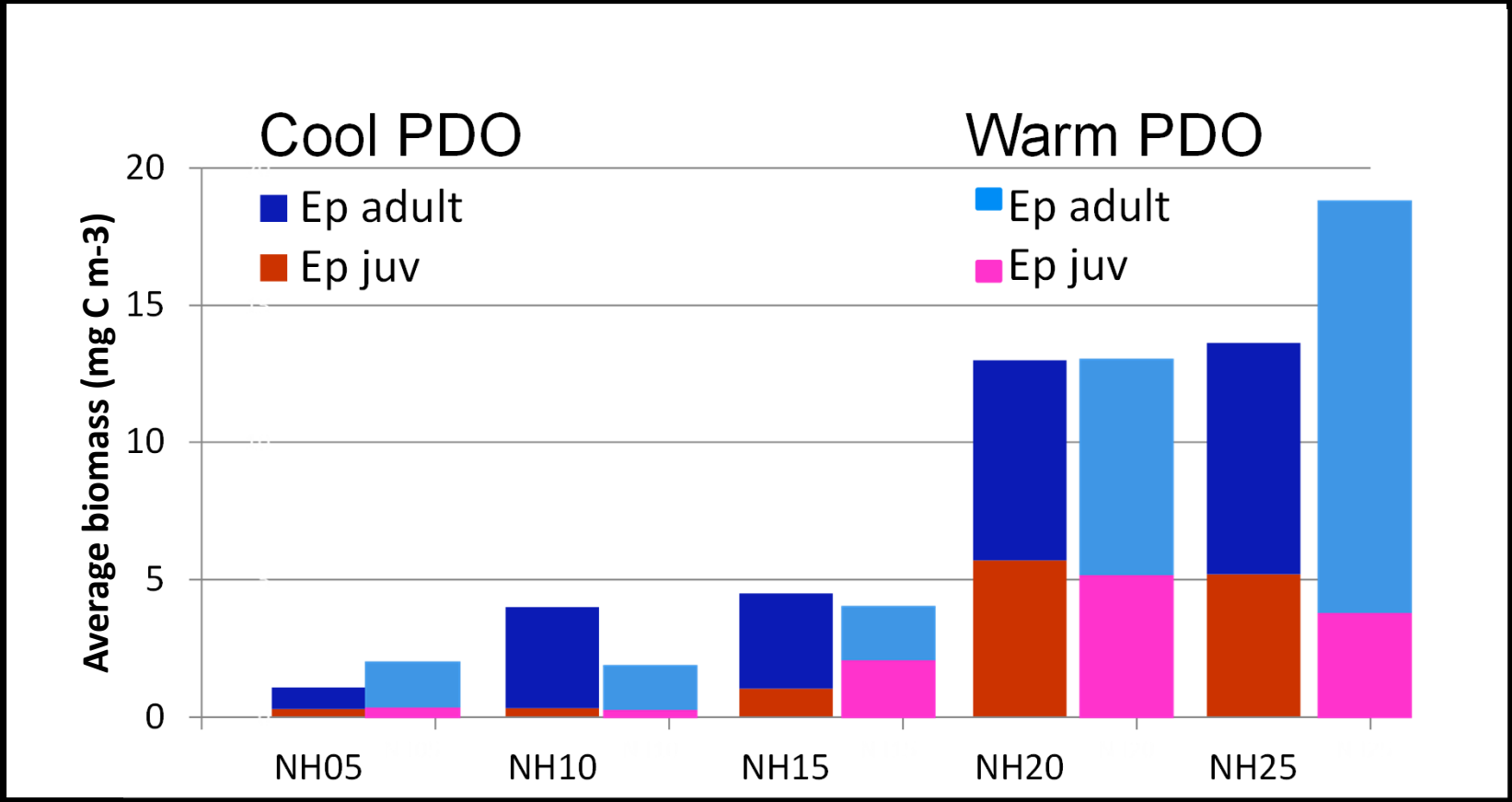
- Climatology 5-10 mg C m^{-3} year-round (but averages aren't everything)
- High interannual variability (or is it patchiness?)
- Lowest biomass consistently in June
- High biomass occurs in both cool and warm years

Biomass – *T. spinifera* adults



- Nov-June ~0.5 mg C m^{-3}
- July-Oct 1-2 mg C m^{-3}
- High interannual variability (or patchiness?)
- Higher biomass values occur in cold years, rare in warm years

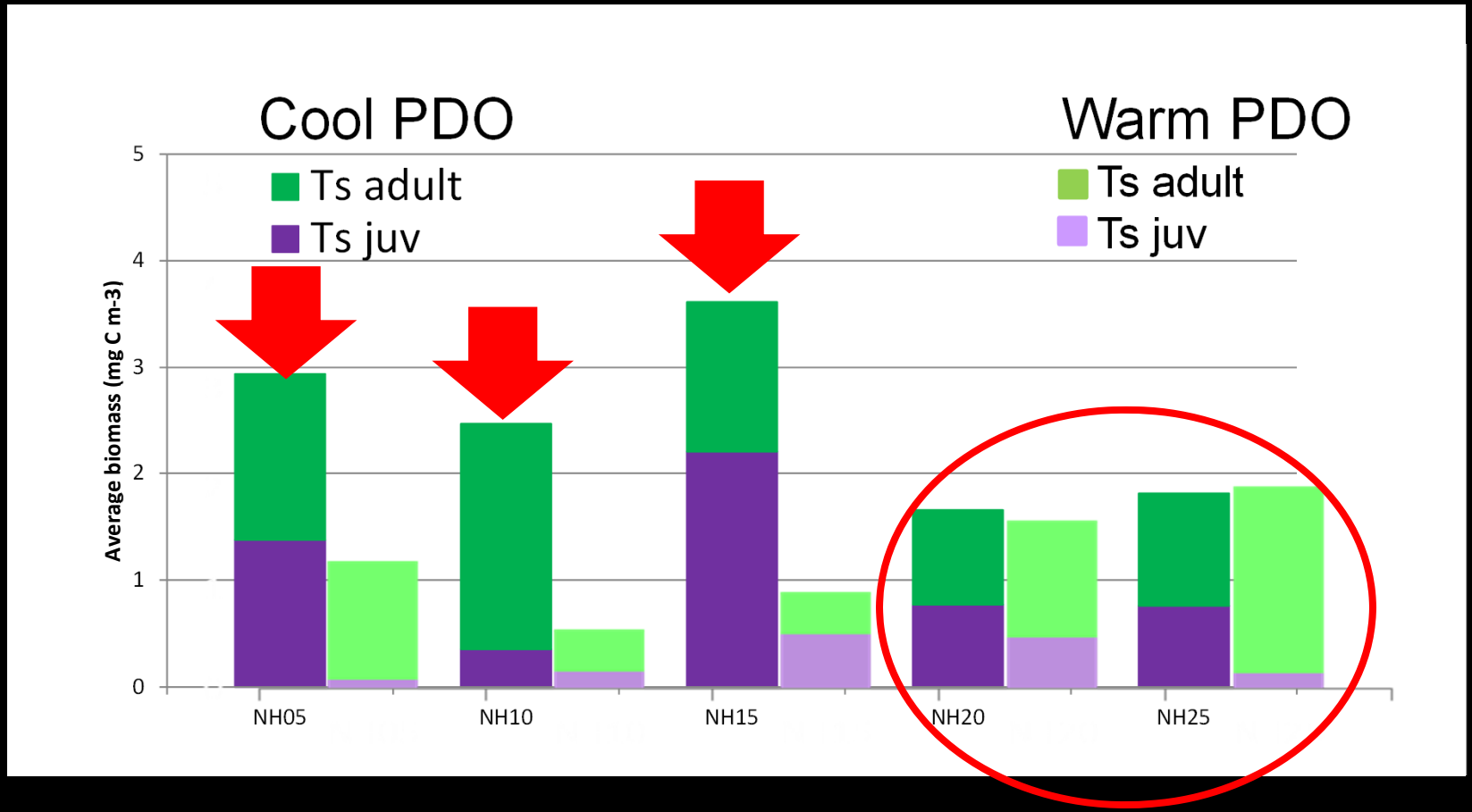
E. pacifica cross-shelf biomass
cool vs. warm PDO



Cross-shelf biomass essentially the same for cool and warm PDO

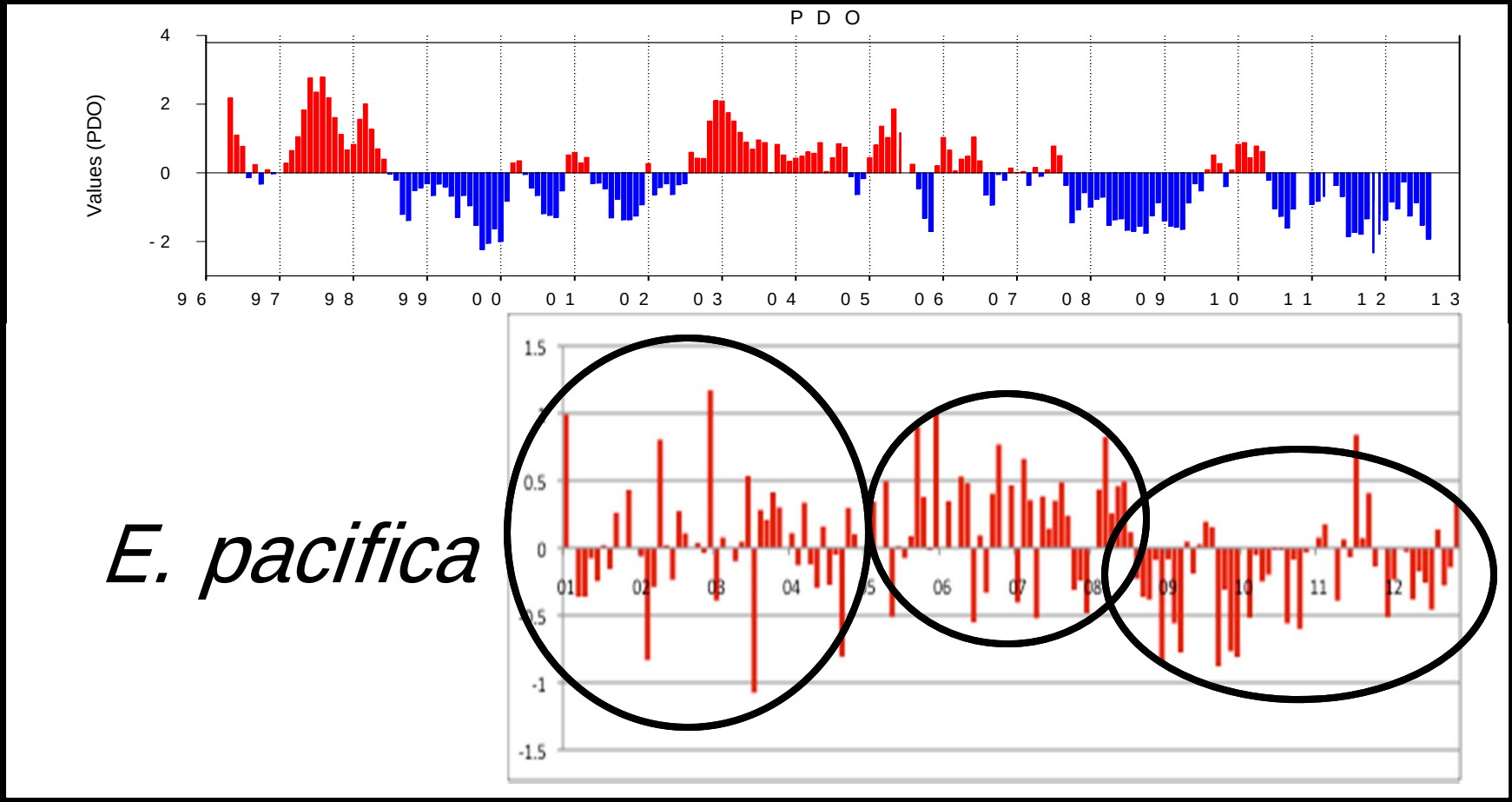
E. pacifica might even prefer a little warming

T. spinifera cross-shelf biomass
cool vs. warm PDO



- Biomass offshore essentially the same for cool and warm PDO
- Biomass inshore decidedly higher during cool conditions

PDO & biomass anomaly

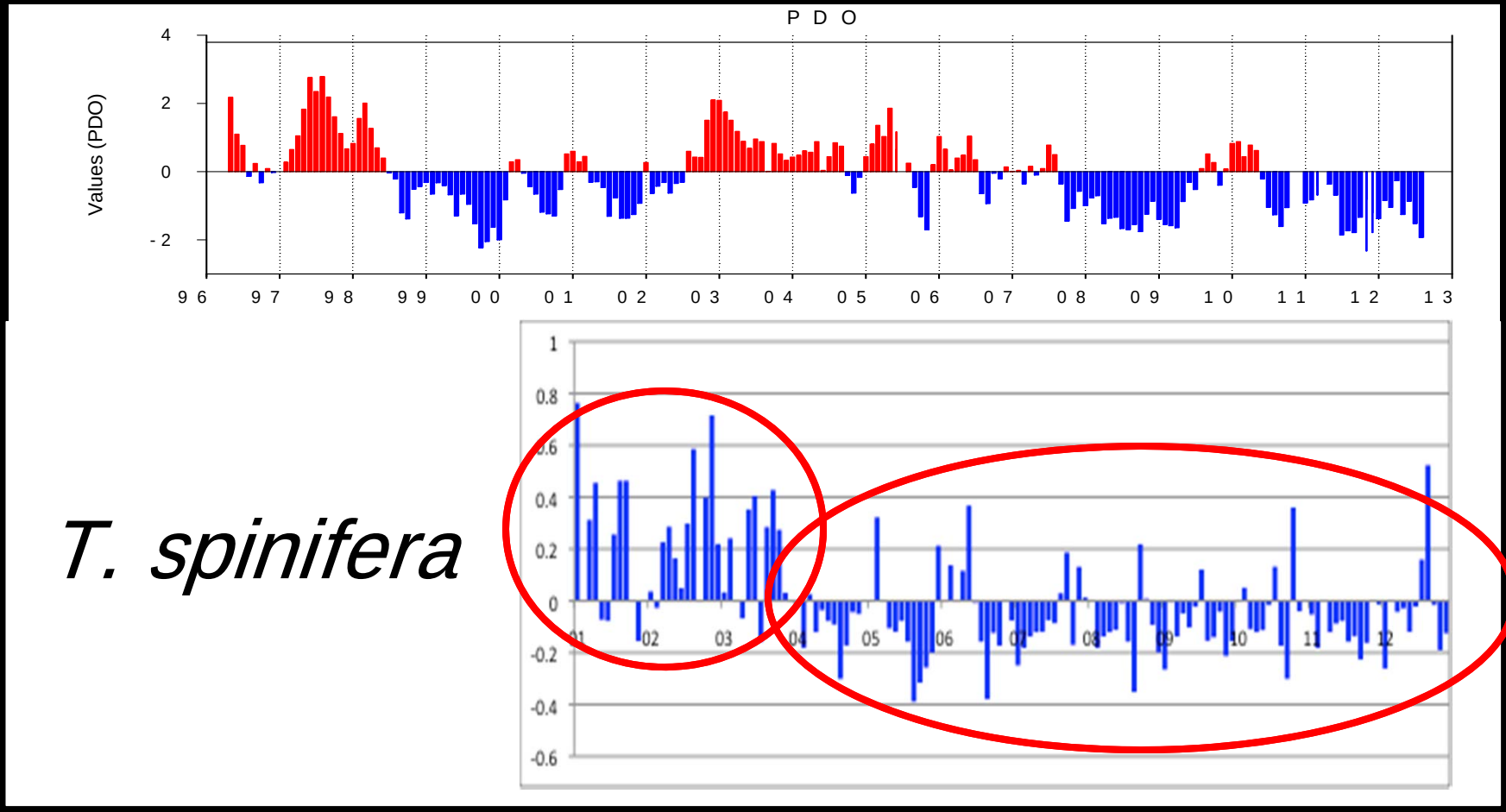


No distinct pattern 2001-2004 (PDO cool ➔ warm)

Predominantly positive 2005 until mid-2008 (PDO warm ➔ cool)

Predominantly negative mid-2008 to present (PDO cool)

PDO & biomass anomaly



- Positive anomaly 2001-2003 even though PDO warm starting 2003
- Largely negative 2004-2012 even though PDO cool starting 2008

Biomass – the general answer

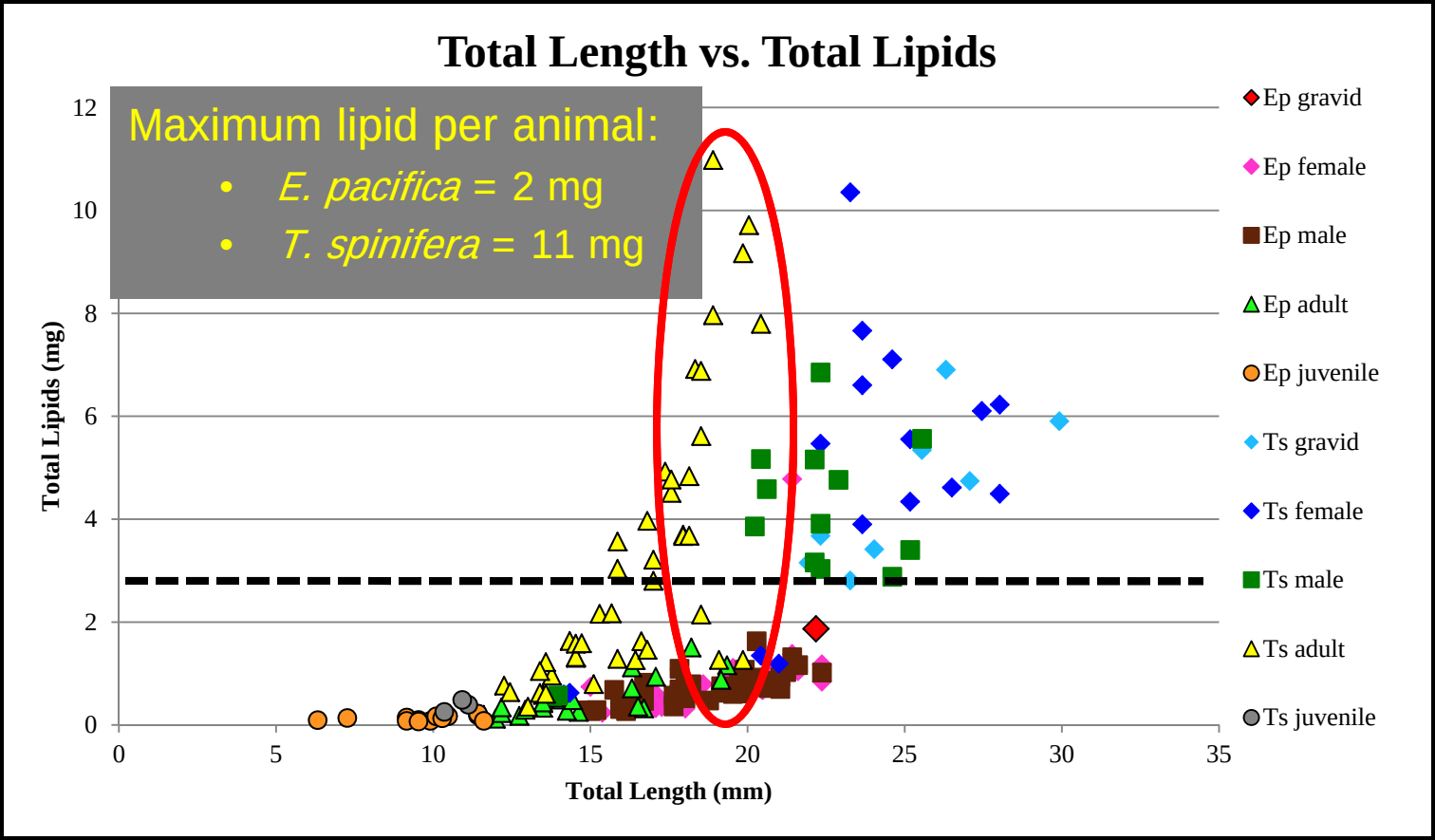
Average biomass (mg C m^{-3})	NH05-NH25	NH20-NH25
E. pacifica	16.45	34.41
T. spinifera	1.41	1.49

- *E. pacifica* more abundant than *T. spinifera*
- *E. pacifica* clearly concentrated offshore
- *T. spinifera* biomass similar inshore and offshore
- Averages are not what matter to predators

Lipid Data Caveats

- Lipid samples are from 2010-2012
  - All lipid measurements from krill collected during cold conditions
  - No data on how lipid content might be affected in warm years
- Lipid data may not represent:
  - Abundance
  - Species composition
  - Length frequency
  - Full range of possible values per length or month category

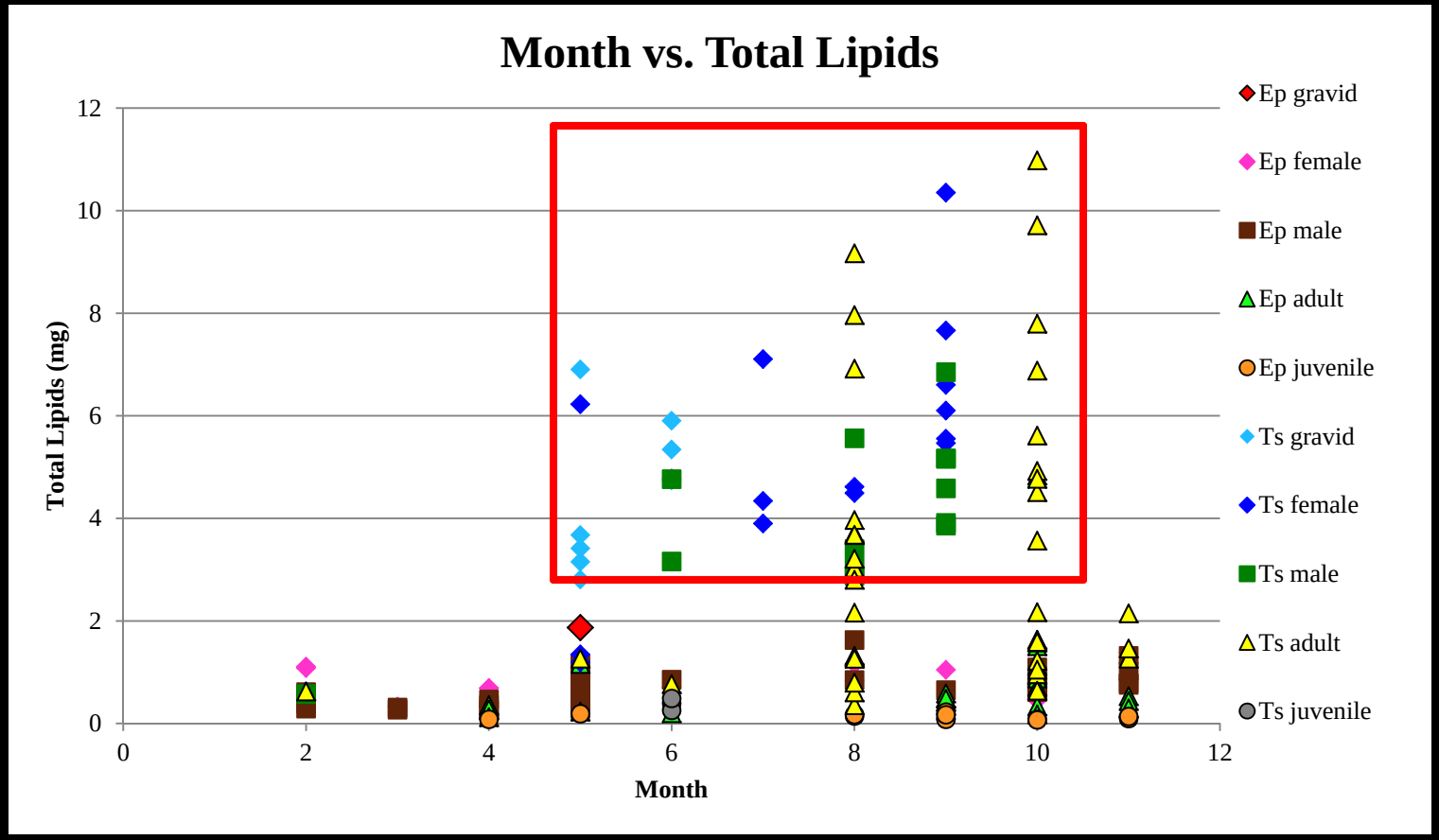
Lipids by length



Large range of lipid content for animals of similar lengths

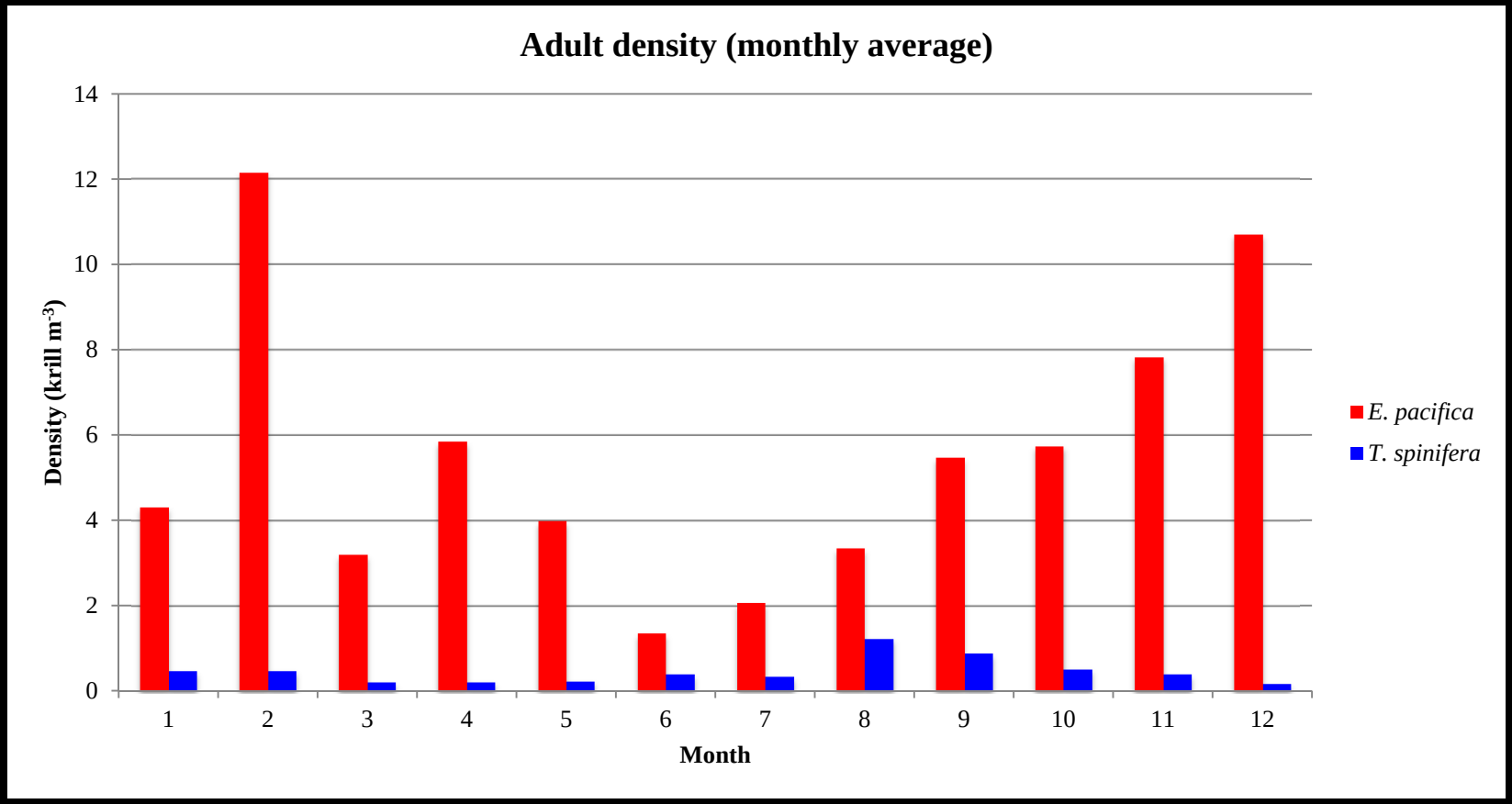
Cannot use length as a proxy for lipid content

Lipids by month

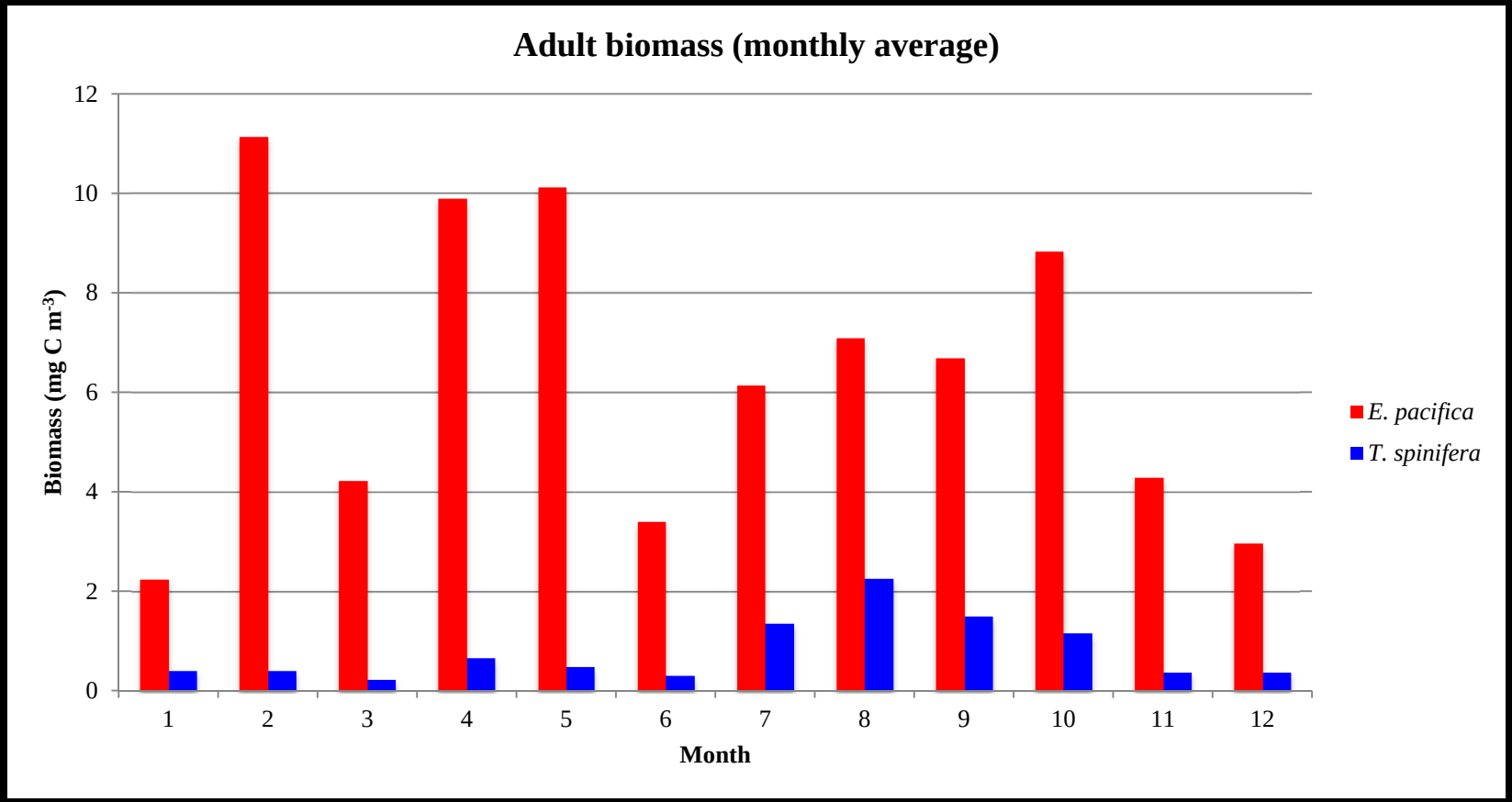


- Lipid >2mg/animal exclusively *T. spinifera*
- Available May-October (~upwelling season)

Adult Density (monthly average)

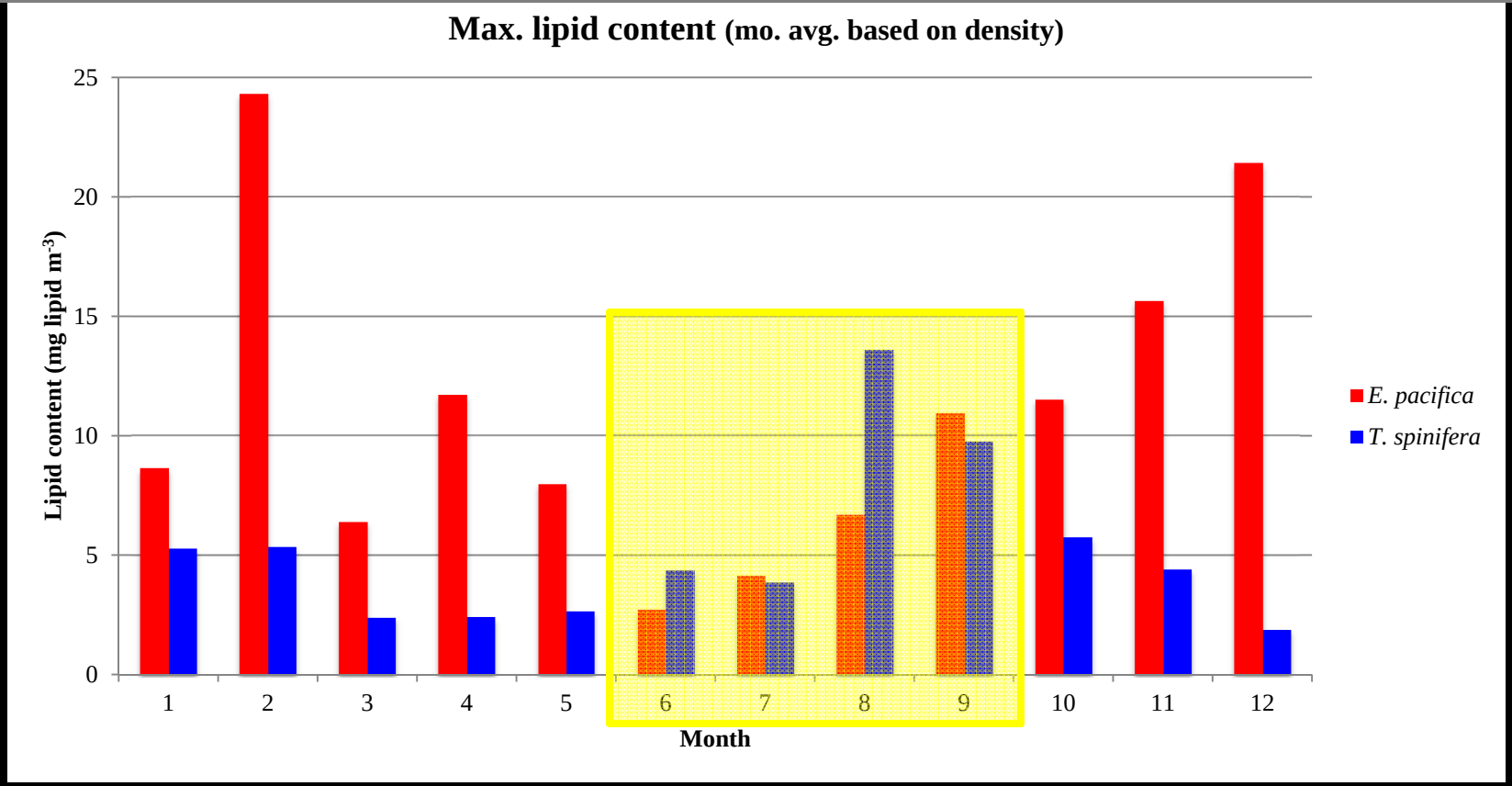


Adult Biomass (monthly average)



Adult Lipid (monthly average)

T. spinifera – lower density than *E. pacifica* but higher lipid content could make them an equally valuable food source



Krill math

- Biomass: 1-2 mg C per adult, both species

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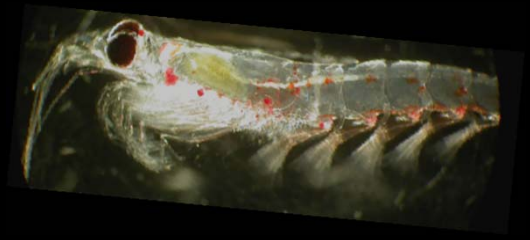

- Lipid content (max. per adult)
  - *T. spinifera* = 11 mg *E. pacifica* = 2 mg

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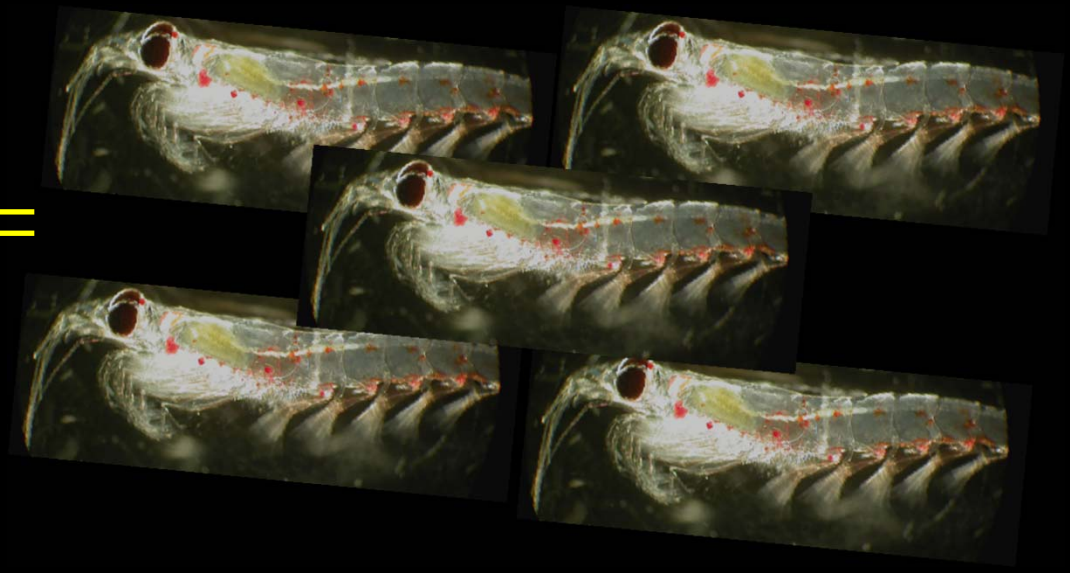
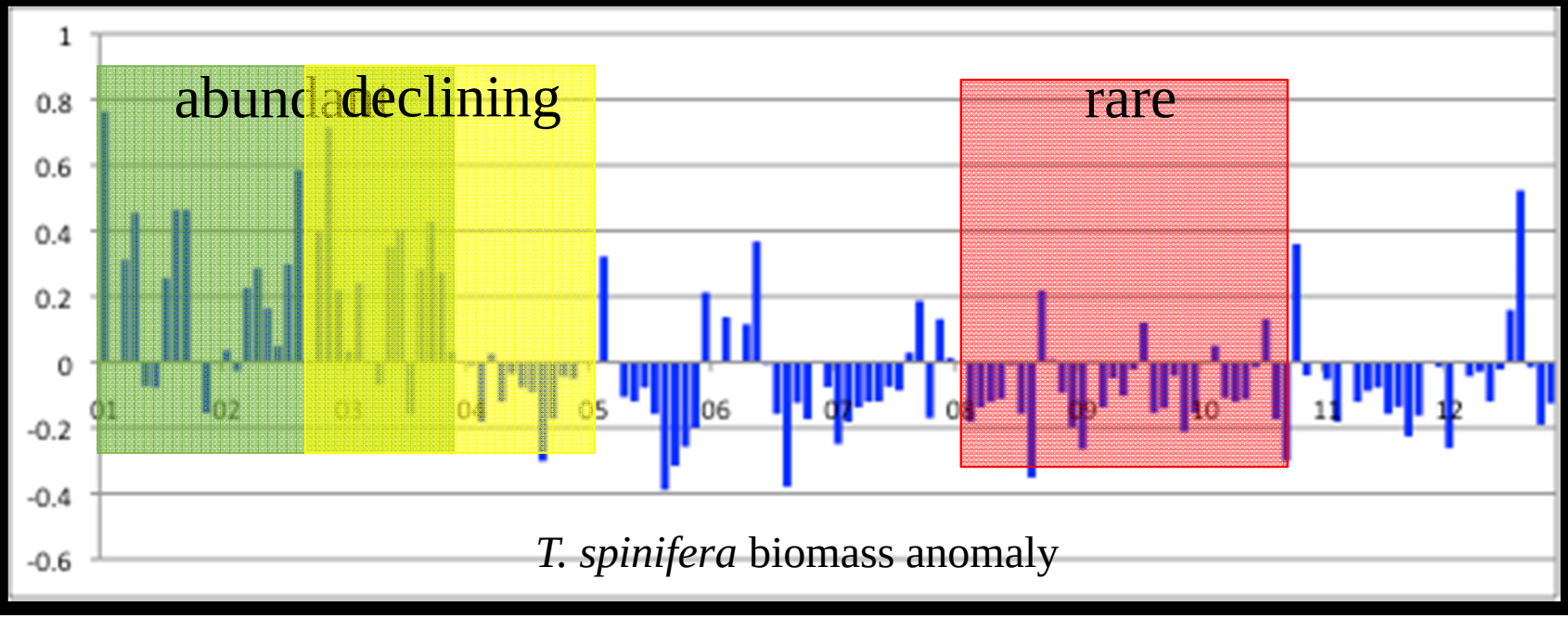


Things to consider...

- Abundance isn't everything
  - *E. pacifica* much more abundant than *T. spinifera*
  - *T. spinifera* may also be an important food source:
    - higher potential lipid per krill
    - inshore distribution
    - availability during upwelling
- Are we measuring what we should be measuring?
  - Density/biomass/carbon may not be the important factors from the perspective of foraging predators
  - How does patchy distribution affect density and biomass estimates?
  - How does this impact modeling efforts?

Value of long-term time series data

How would our view of euphausiid population dynamics off the Oregon coast differ if it were based on any consecutive 3-year time period from the last 12 years?



Future Plans?

- Zooplankton ecologist specializing in krill
- Experience includes:
  - Work in Antarctica, Bering Sea, Oregon Coast, Yellow Sea
  - Sorting preserved zooplankton samples
  - Experiments with live euphausiids
  - Working at sea on large and small research vessels
- Available January 2014
- Contact: tracy.shaw@noaa.gov
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Acknowledgements

- Research vessels: *Elakha*, *Wecoma*, *Atlantis*, *Frosti*, *Miller Freeman*, *McArthur II*, *New Horizon*, *Shimada*
- Funding sources: NOAA/NWFSC, ONR/NOPP, NSF/CoOP/COAST, NOAA-GLOBEC, NSF/CoOP/RISE, NOAA-SAIP
- My co-authors (and Jay):



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