Seasonal comparison of abundance, growth, and spawning of *Euphausia pacifica* and *Thysanoessa spinifera* off the Oregon Coast

Euphausia pacifica

Thysanoessa spinifera

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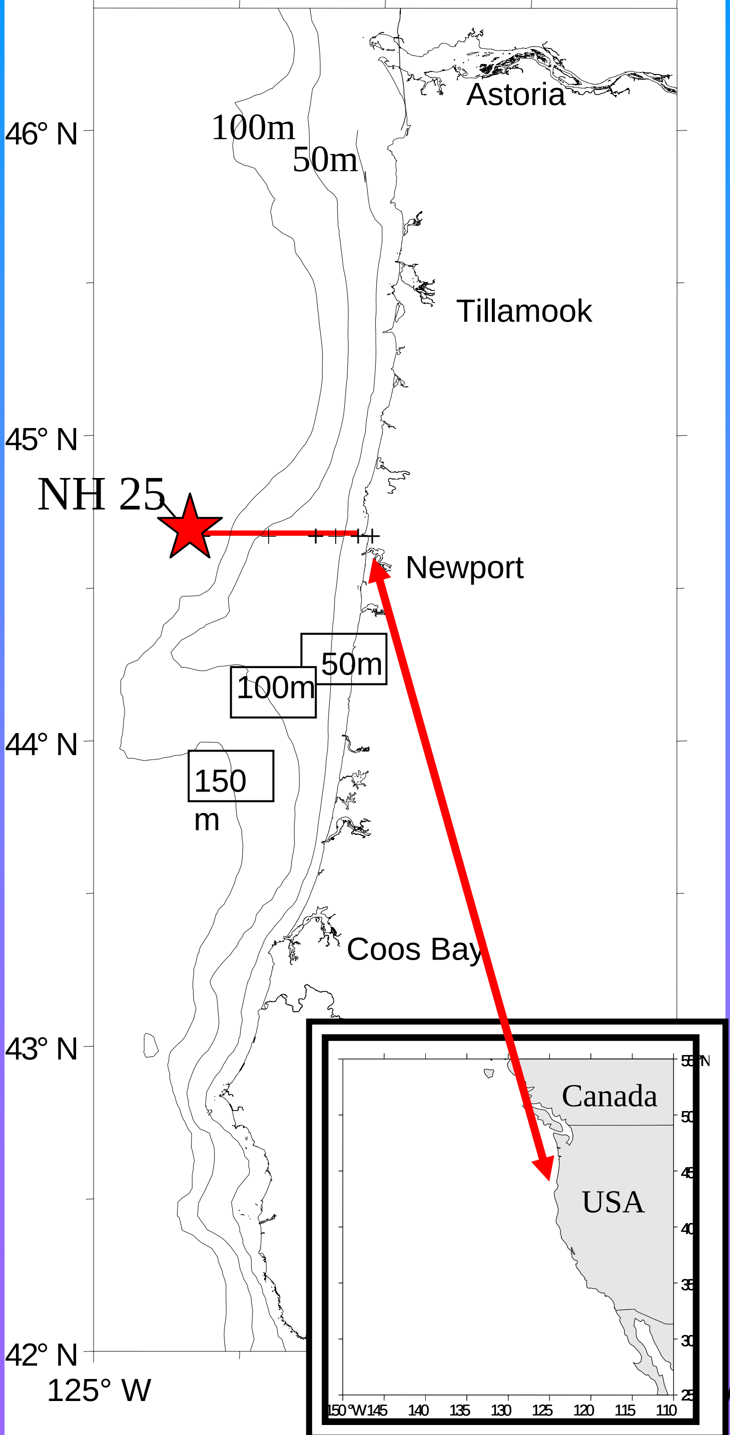
NH-Line Time Series



- Sampled twice per month by the Peterson lab since 1996
- Adult euphausiids sampled starting in 2001 with access to a larger (54’) vessel
- Growth rate and egg production experiments on live animals conducted regularly since 2001
- Data for this talk from station NH25 (★) at the shelf break
- *E. pacifica* and *T. spinifera* distributions overlap at this station

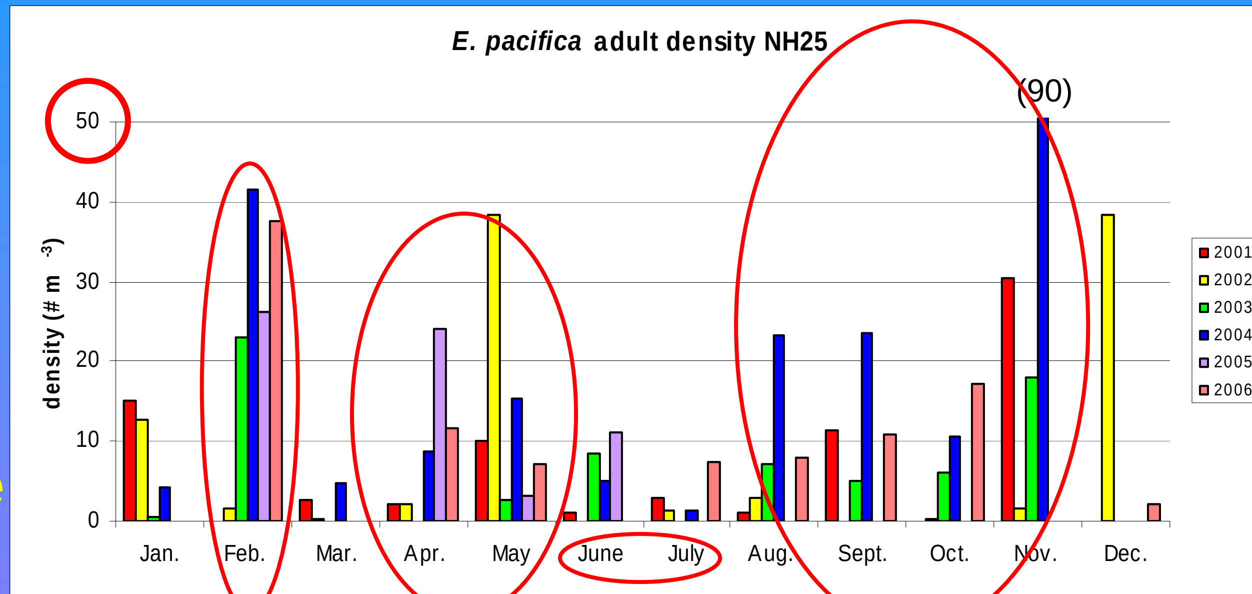
Seasonal comparison

- Two seasons in the ocean off the Oregon coast – upwelling and downwelling
- Seasons defined by timing of spring and fall transitions (Logerwell et al. 2003)
- Median spring transition date (=upwelling) **April 18** (range March 2 - May 26)
- Median fall transition date (=downwelling) **Oct. 27** (range Sept. 13 - Nov. 17)
- More accurate to use transition dates specific to each year than to designate certain months as upwelling or downwelling

Density of adult euphausiids

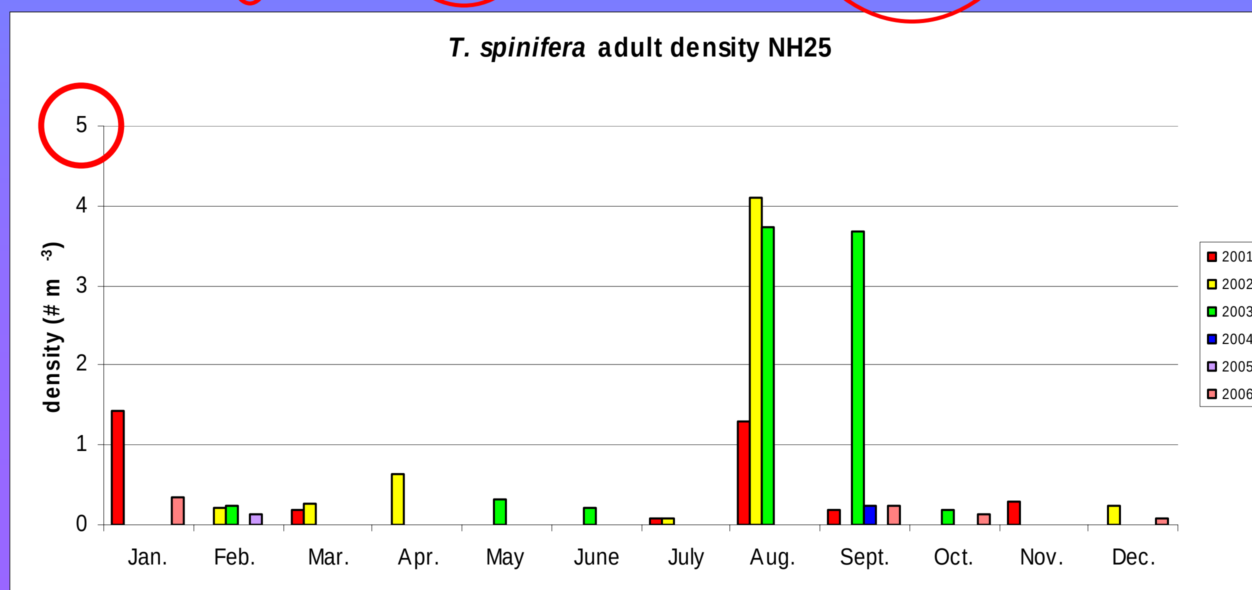
E. pacifica adults

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

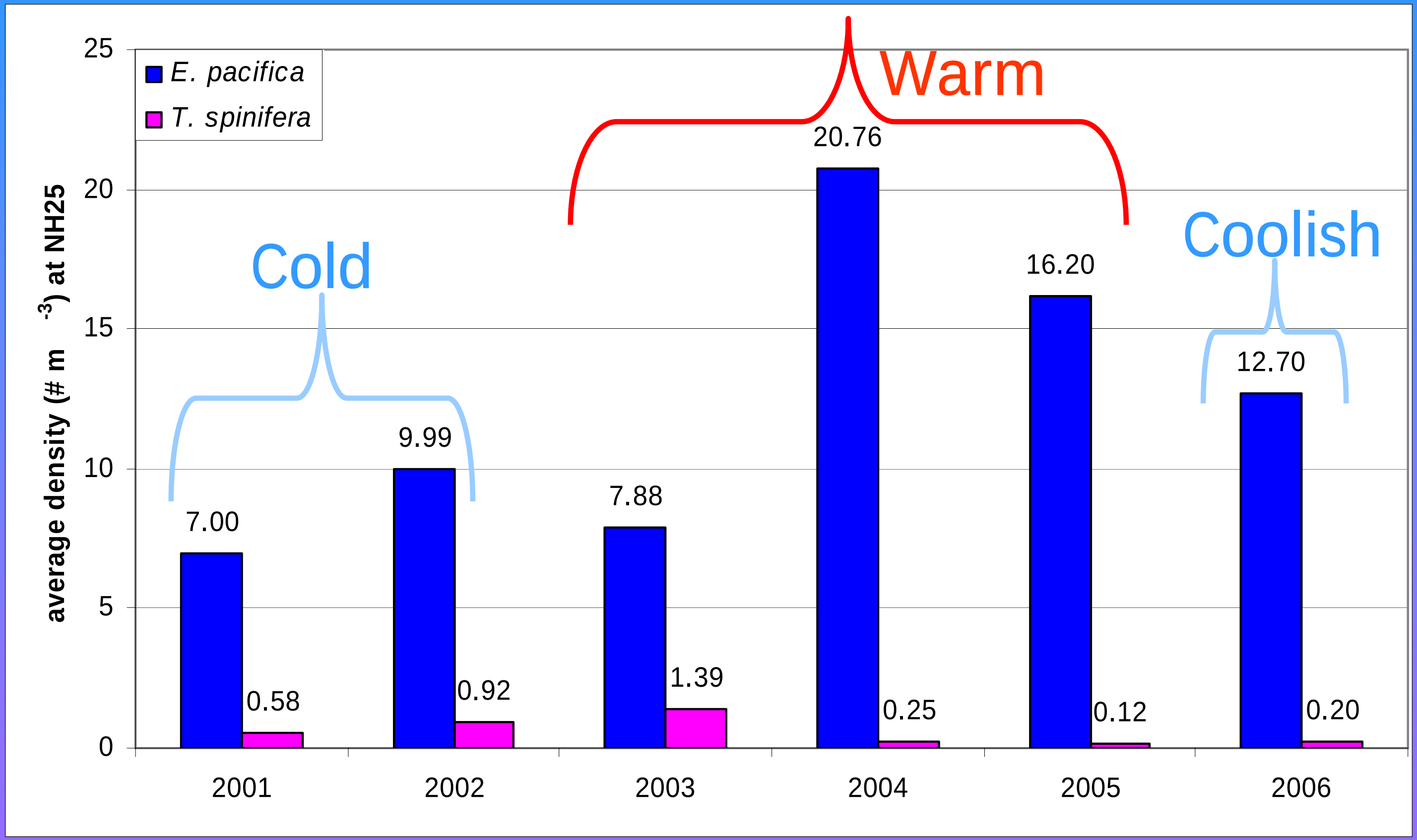


T. spinifera adults

- Never very abundant at NH25
- Highest abundance Aug-Sept, 3-4 animals m^{-3}



Average euphausiid density

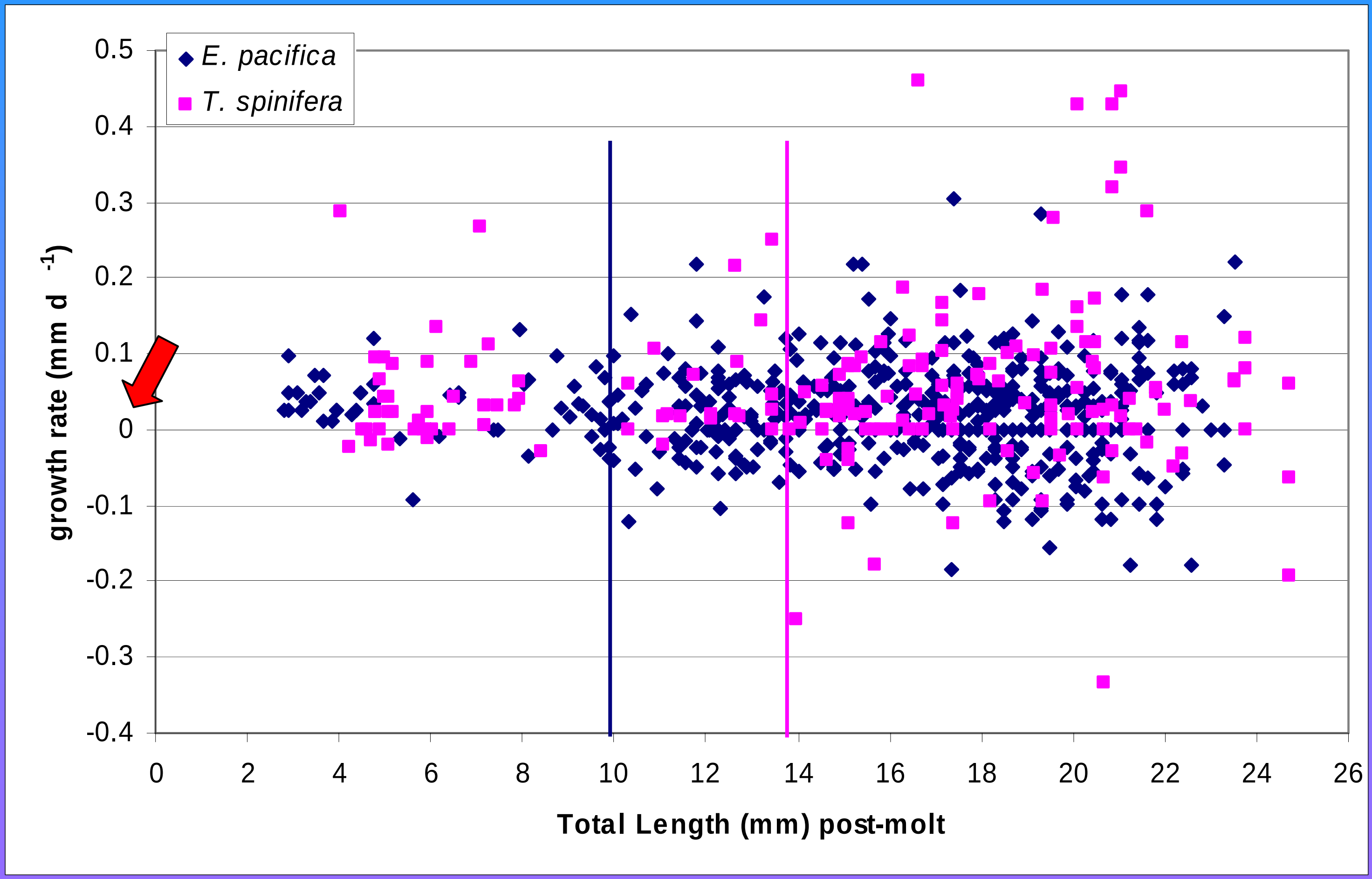


No clear relationship with the temperature variation in our study area during the past six years

Measuring growth of live euphausiids

- Instantaneous growth rate (IGR) protocol
- IGR method assumes molting is random
- Euphausiids caught in oblique tows to 25 m at night
- Incubate individual animals in jars for 48 hr
- Check every 12 hr for molts
- Measure telsons of preserved molt and animal to get growth increment
- Experiments focused on adults and juveniles

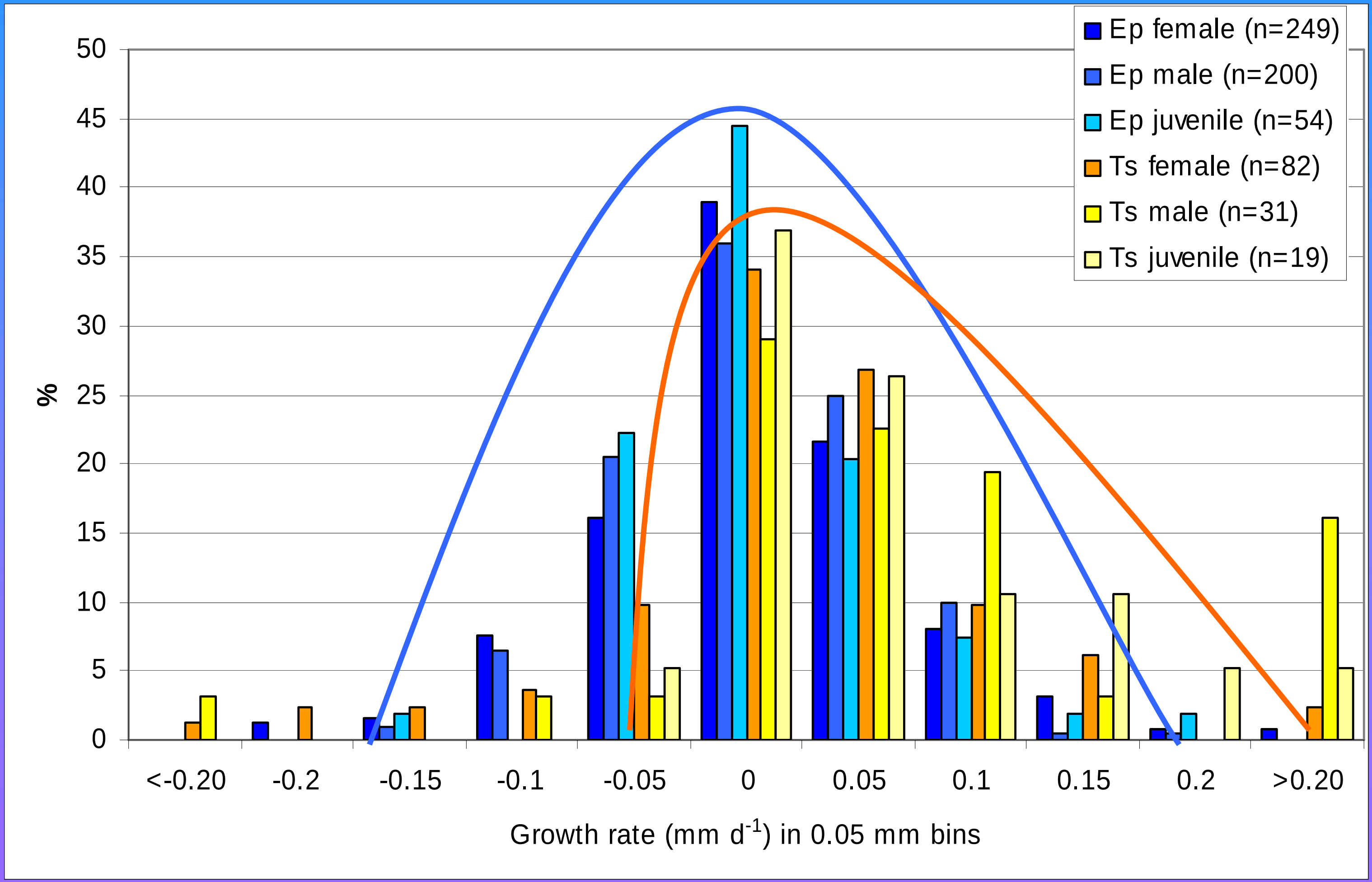
Growth rates – both species



Negative growth:
E. pacifica > 10 mm
T. spinifera >14 mm

T. spinifera mature (and start reproducing) at a larger size than *E. pacifica*, hence the later incidence of negative growth.

Growth rates – both species



- *E. pacifica* positive and negative growth rates evenly distributed
- *T. spinifera* growth rates skewed towards positive growth

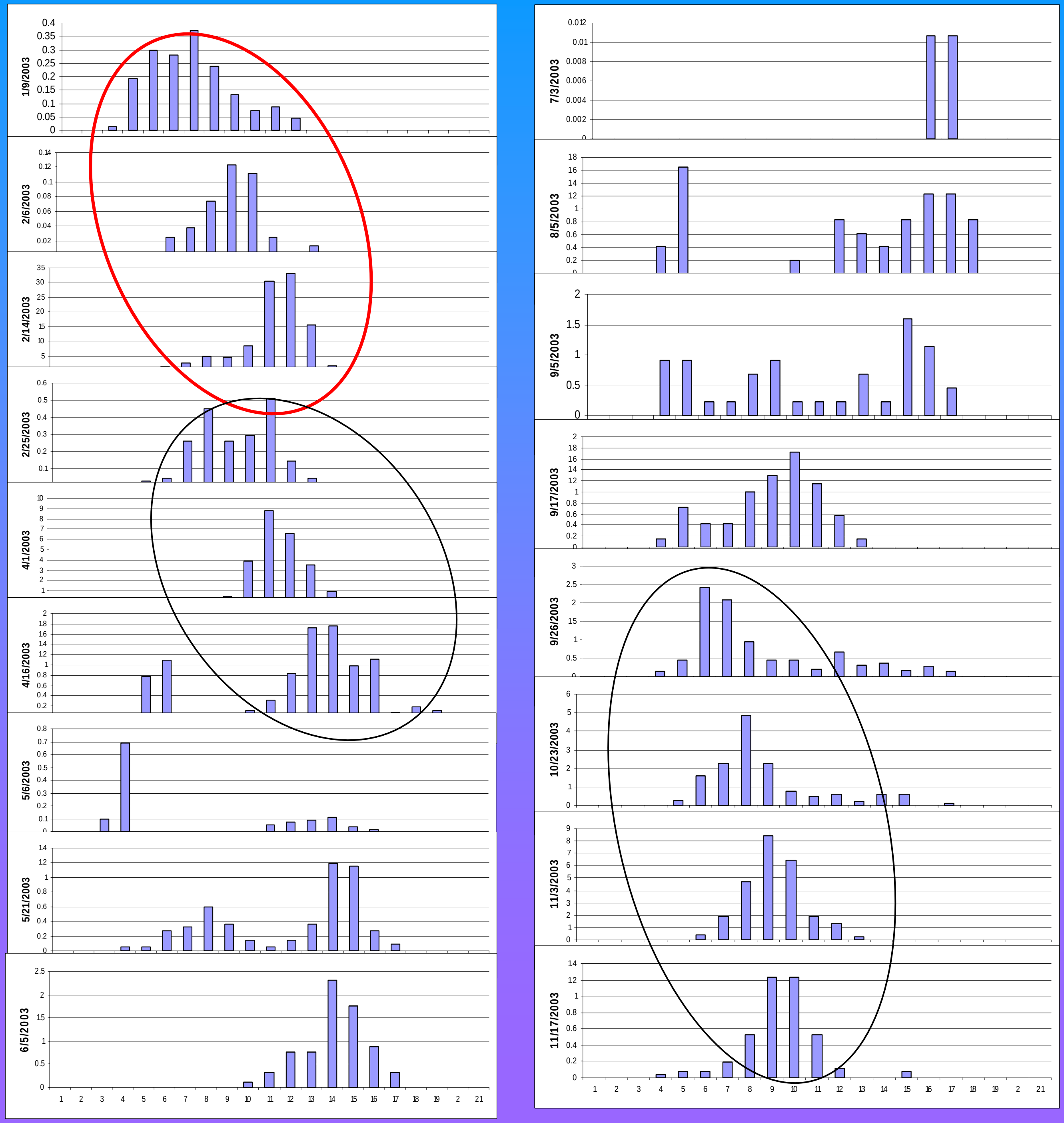
Calculating growth from cohort data – *Euphausia pacifica*

- Cohort data for *E. pacifica* only due to low numbers of *T. spinifera* in our catches
- Used samples from a single station (NH25)
- Counted and measured preserved adult and juvenile euphausiids
- Plotted densities in 1 mm length bins

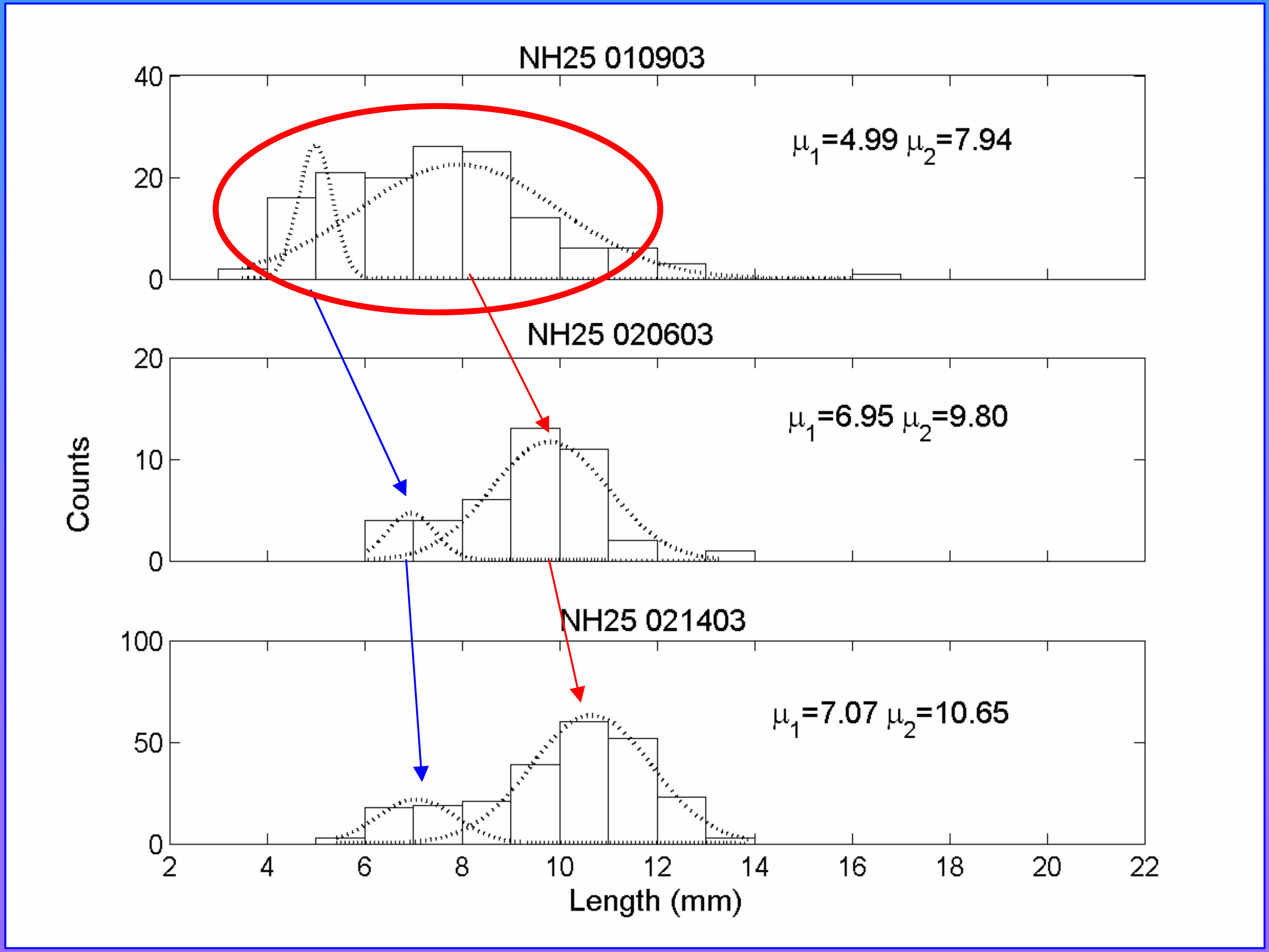
Raw Cohort Data 2003

We can calculate growth rates from change in cohort mean length over time.

This allows us to compare **measured** growth from IGR experiments with **calculated** growth from cohort data



Cohorts from maximum likelihood method

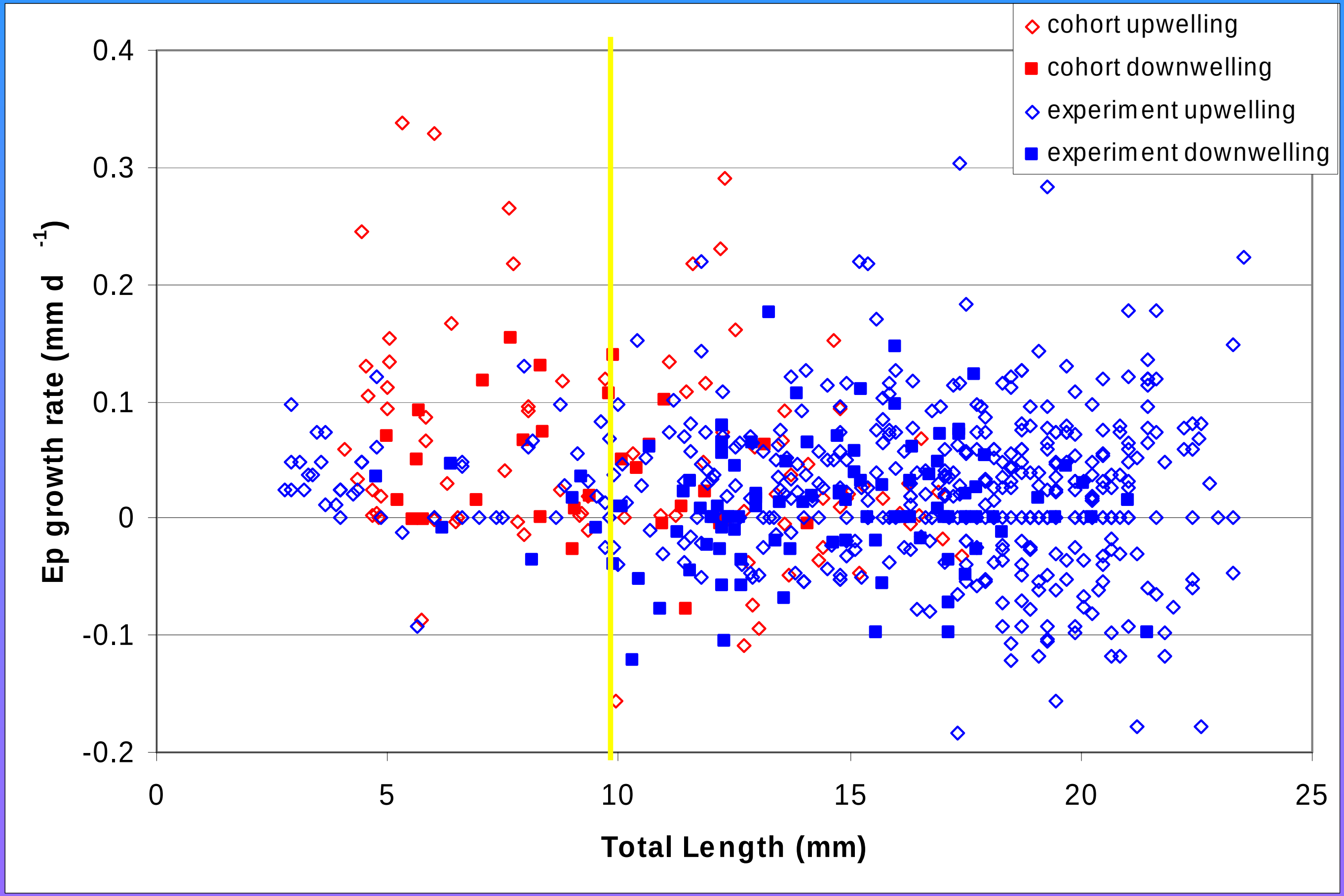


- This technique identifies overlapping distributions that could not be determined by eye
- We calculated growth rates from change in mean length of cohort from one sampling date to the next

Comparison of experiment and cohort data (*E. pacifica*)

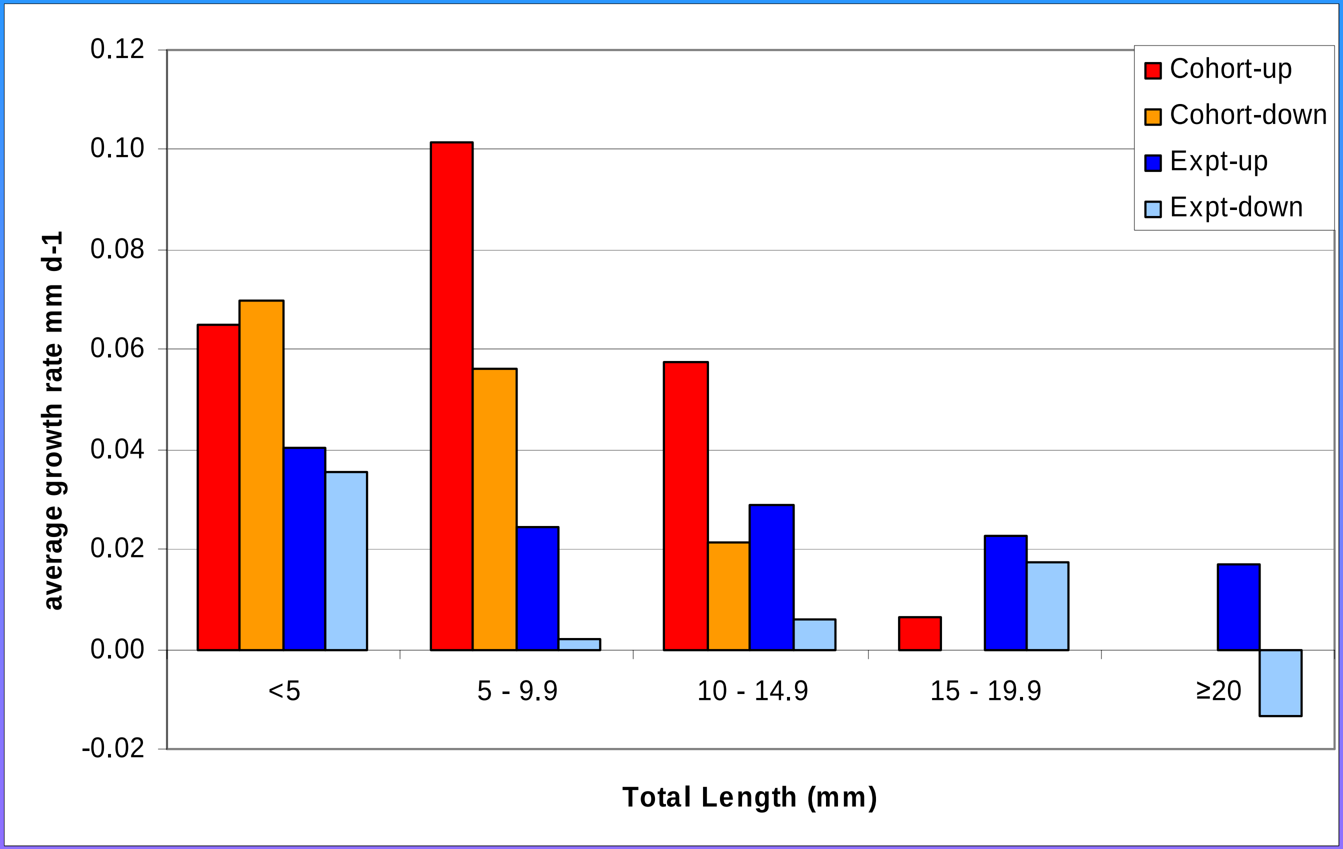
Experiment data	Cohort data
• Growth rate for each individual animal that molts	• Growth rate for each mode in the size frequency (1-3 growth rates for each pair of samples)
• Range of individual variability at one point in time	• Average growth over time interval between samples (usually 2 weeks)
• Individual growth rates often zero or negative	• Rarely able to capture negative or zero growth with cohort data

Comparison of experimental and cohort growth rates by size (*E. pacifica*)



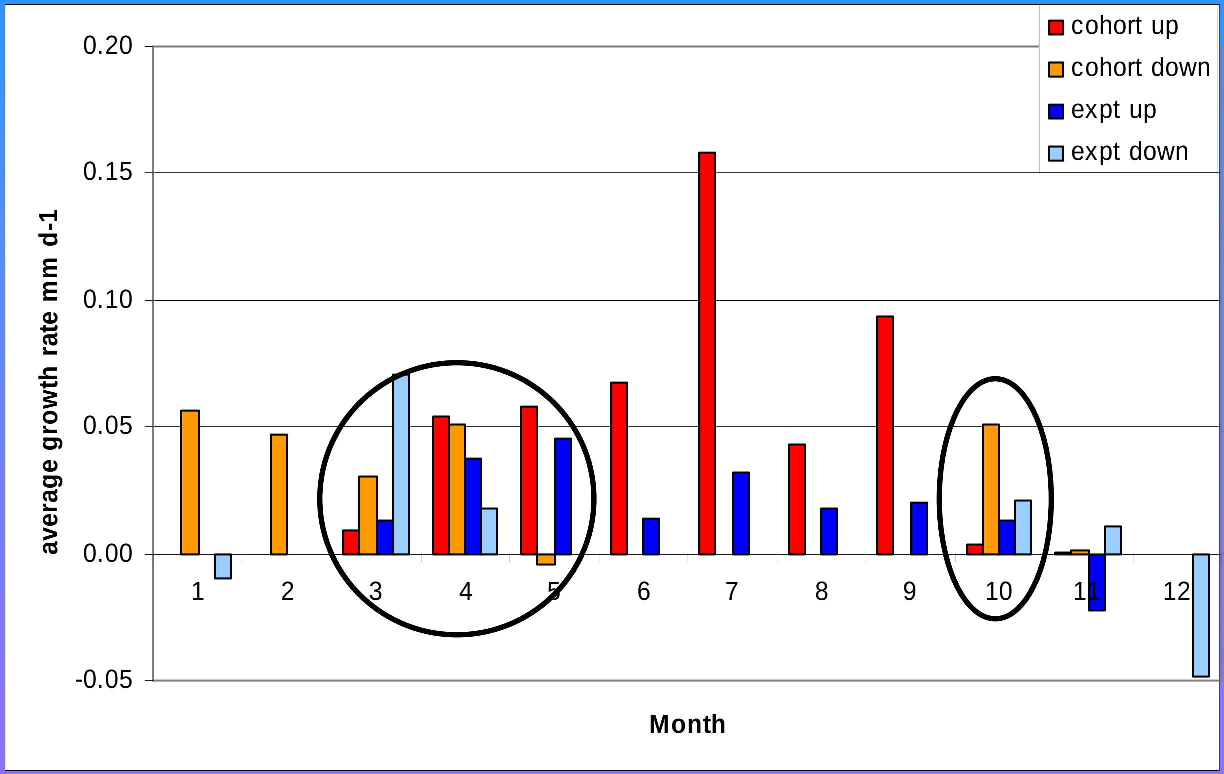
- Cohort lengths are modes of length distributions, hence not as large as individual size distribution
- Negative growth rare for animals <10mm with both methods

Average growth rates by size bin



- Average individual growth rates usually lower than cohort rates
- Growth rates positive for small animals (<5 mm) during upwelling and downwelling
- No cohort rates in >20 category because lengths represent modes in size frequency distribution

Average growth rates by month



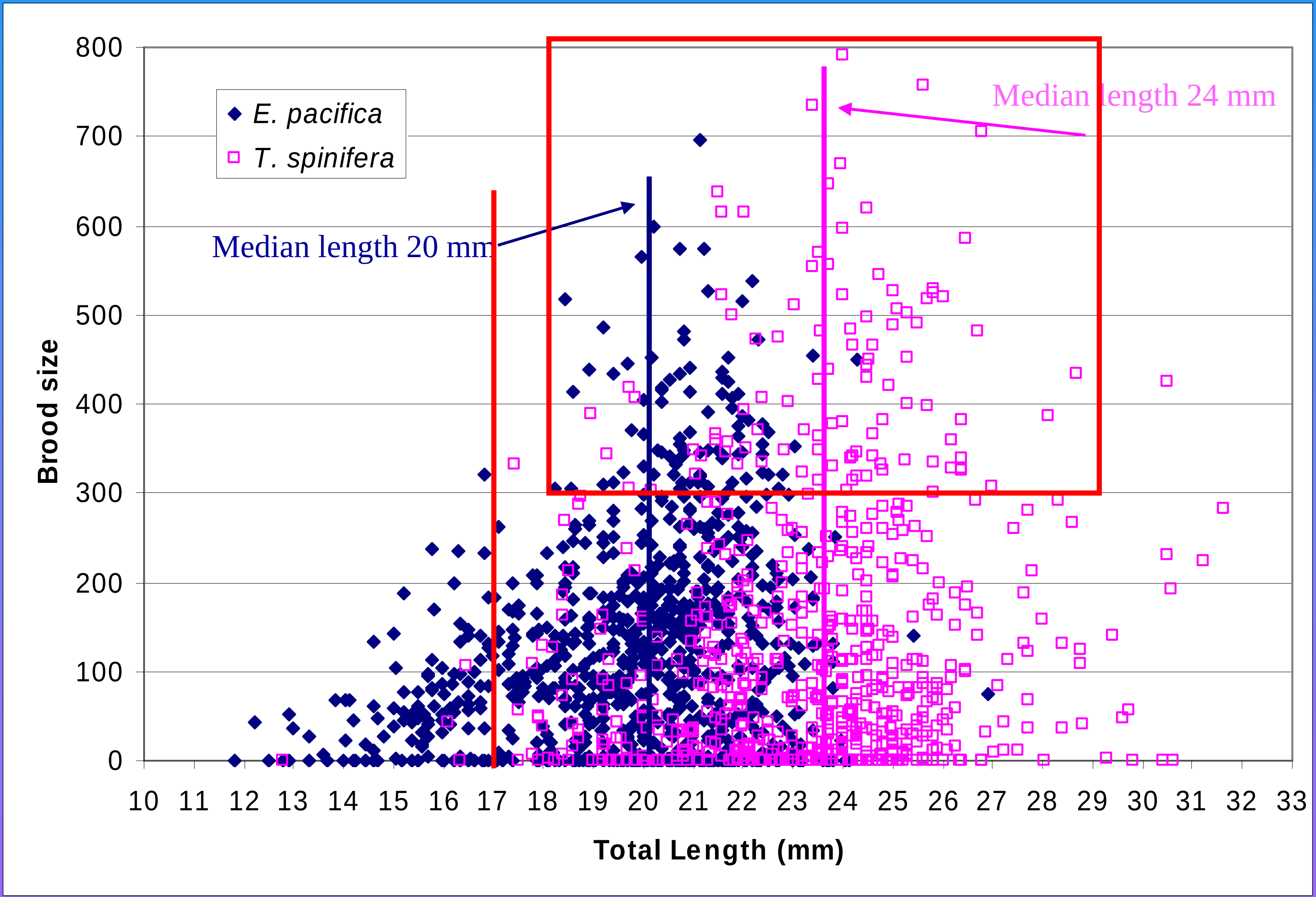
- Overlap in upwelling & downwelling seasons: Mar-May and Oct-Nov.
- Average growth rates from both methods are usually positive
- Upwelling growth rates always positive for cohorts and usually positive for experiments

Growth during downwelling may be negative or positive. Negative growth usually occurs during downwelling.

Brood size and spawning season

- Brood size = number of eggs produced by one female during a 48 hour incubation
- Spawning season determined by presence of eggs in vertical net samples and presence of females with ripe ovaries in bongo net samples
- Spawning usually Feb-Oct in our study area with *T. spinifera* starting earlier than *E. pacifica*
- *E. pacifica* intense period of spawning from ~May-Aug, no corresponding period for *T. spinifera*
- Virtually all spawning occurred during upwelling conditions

Brood sizes – both species



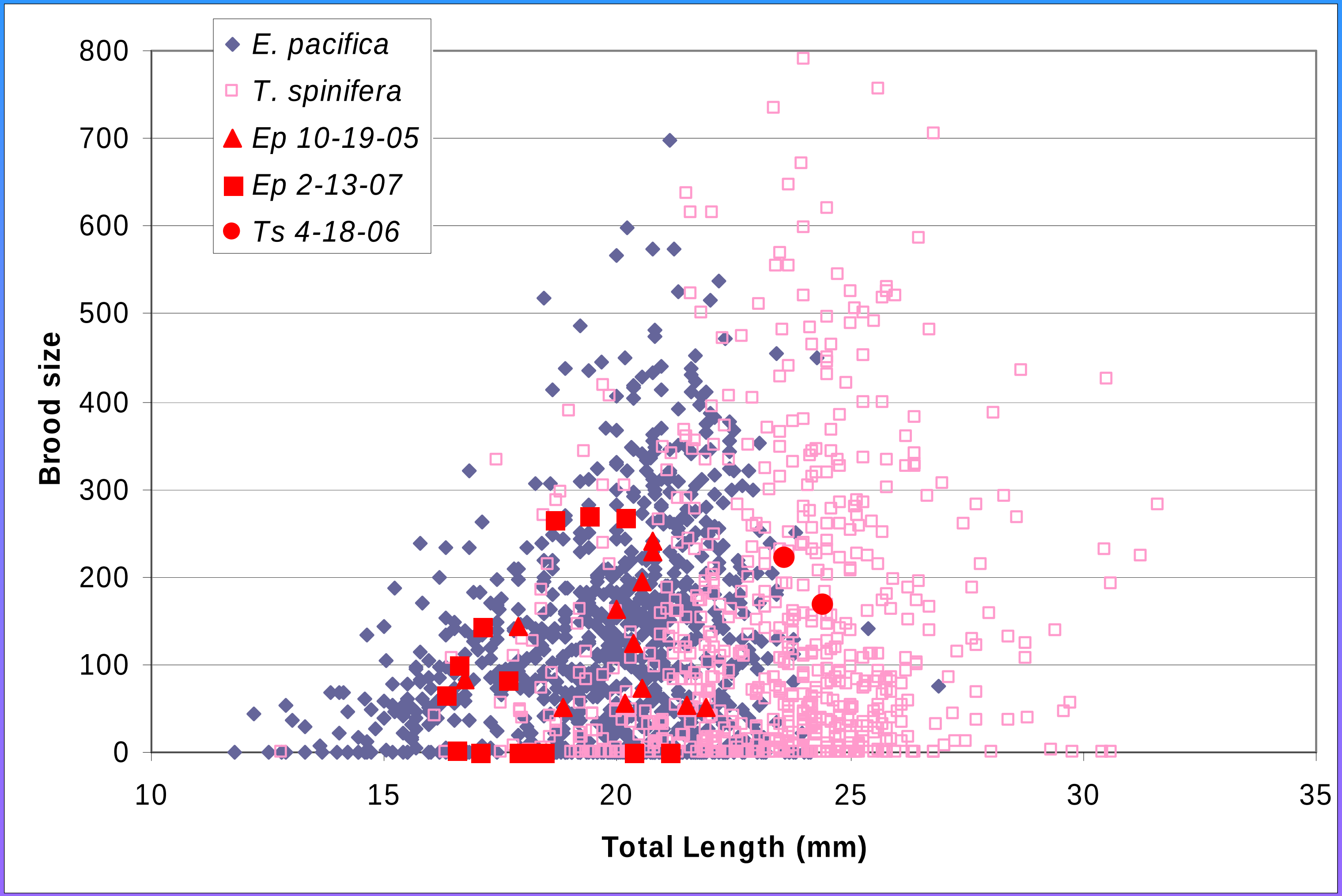
Species	Smallest spawner	Largest spawner	≥400 eggs
E. pacifica	12 mm	27 mm	18-24 mm
T. spinifera	17 mm	32 mm	20-30 mm

Large broods always come from large females, but large females do not always produce large broods.

Large broods are probably an occasional occurrence in both species.

Large broods may be related to optimal feeding conditions.

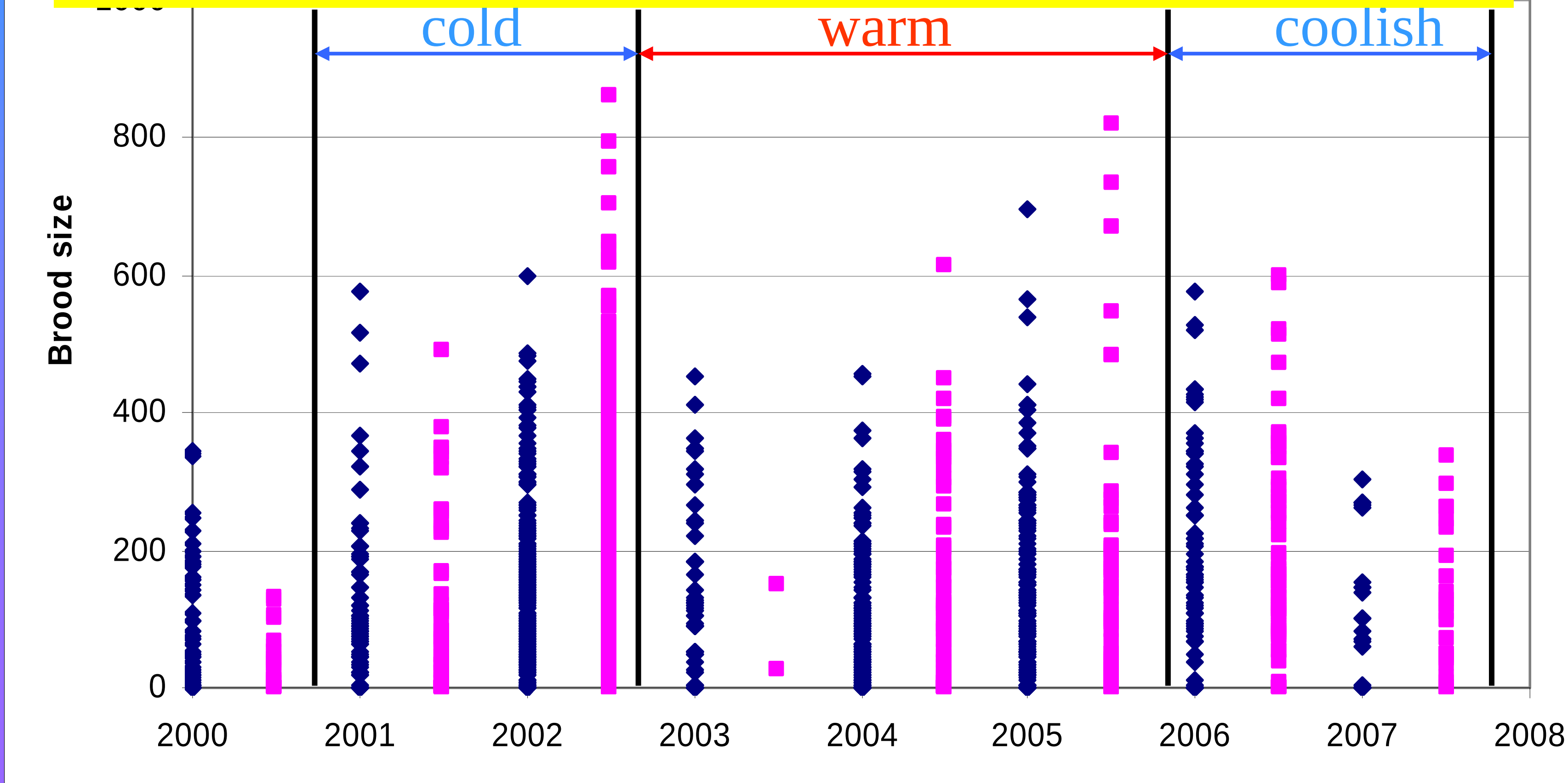
Downwelling brood sizes



Spawning activity rarely occurs during downwelling

Climate influence on brood sizes?

No obvious difference between cold and warm years. Effects of temperature variability may be more difficult to measure: number of females spawning, number and frequency of broods.



Summary of Results

Topic	*E. pacifica*	*T. spinifera*
Density	7-20 animals m^{-3}	0-1.4 animals m^{-3}
Growth	**most growth rates ± 0.1 mm d^{-1}**	
	normal distribution of positive and negative growth rates	positive growth more frequent than negative growth
Cohort data	similar to rates from live experiments	not abundant enough for this analysis
Brood size	max 700 eggs	max 1000 eggs
	larger females able to produce larger broods	
	spawning negligible during downwelling	

Consequences of climate variability for euphausiids?

- No clear interannual signal in abundance, growth or spawning in relation to the temperature variability during this study (2001-2006) – temperature range maybe not high enough to strongly affect euphausiids
- *T. spinifera* have been shown to expand their habitat use in response to cooler temperatures (Gómez-Gutiérrez et al. in press) so warming may restrict their range or shift it north
- Because spawning occurs almost exclusively during upwelling, changes in the timing, duration, or strength of the upwelling season will influence euphausiid reproduction, which will in turn affect their abundance and availability as a food source for higher trophic levels

Acknowledgements

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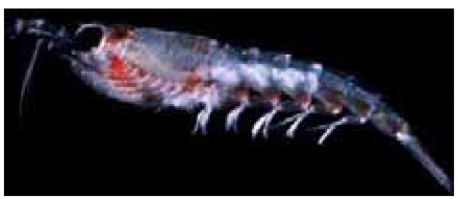
Euphausiid Live Work Protocol

Protocols for Measuring Molting Rate and Egg Production of Live Euphausiids



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

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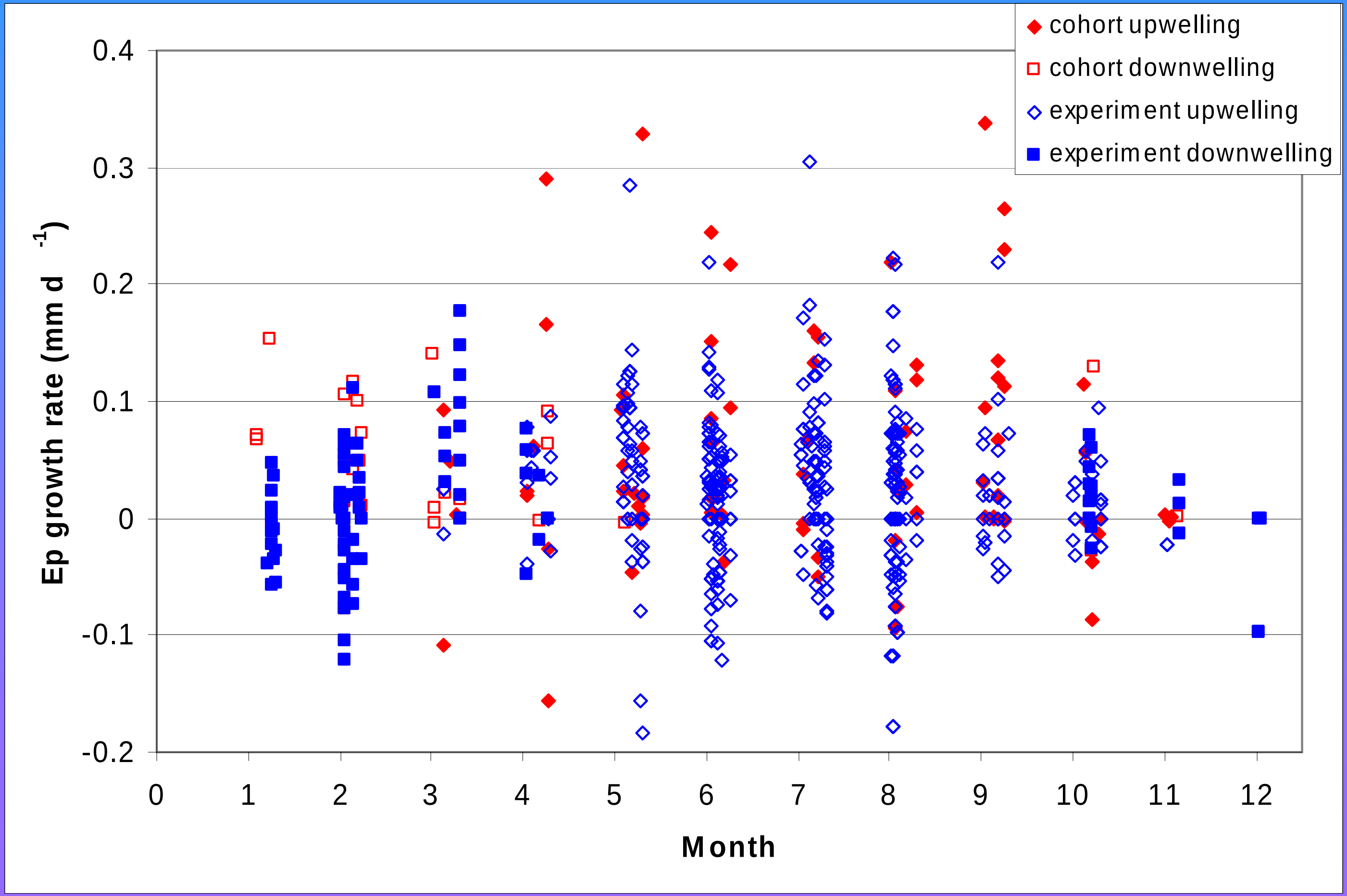
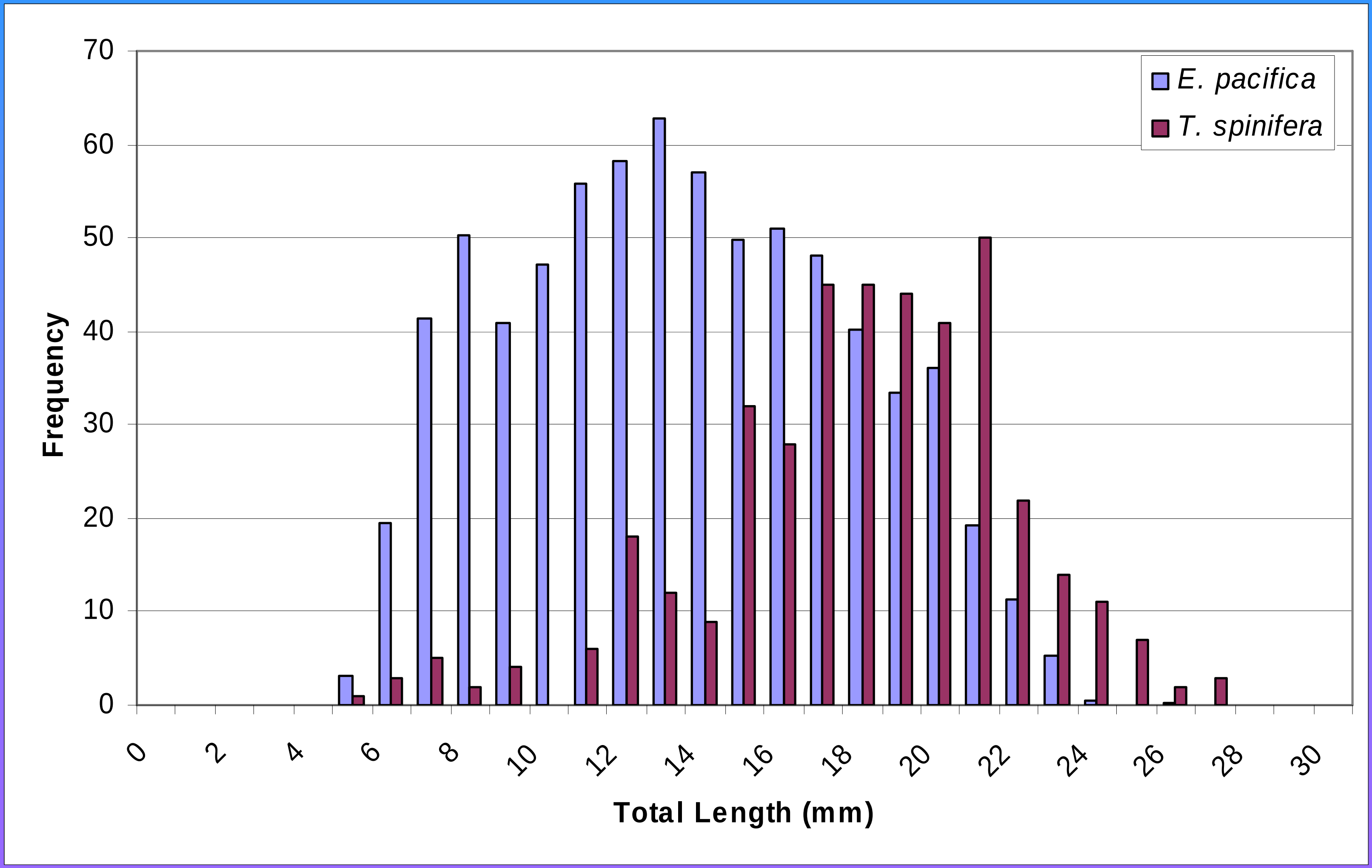
- Everything you always wanted to know about working with live euphausiids!
- Available on the PICES website! (www.pices.int) under the “Projects” heading

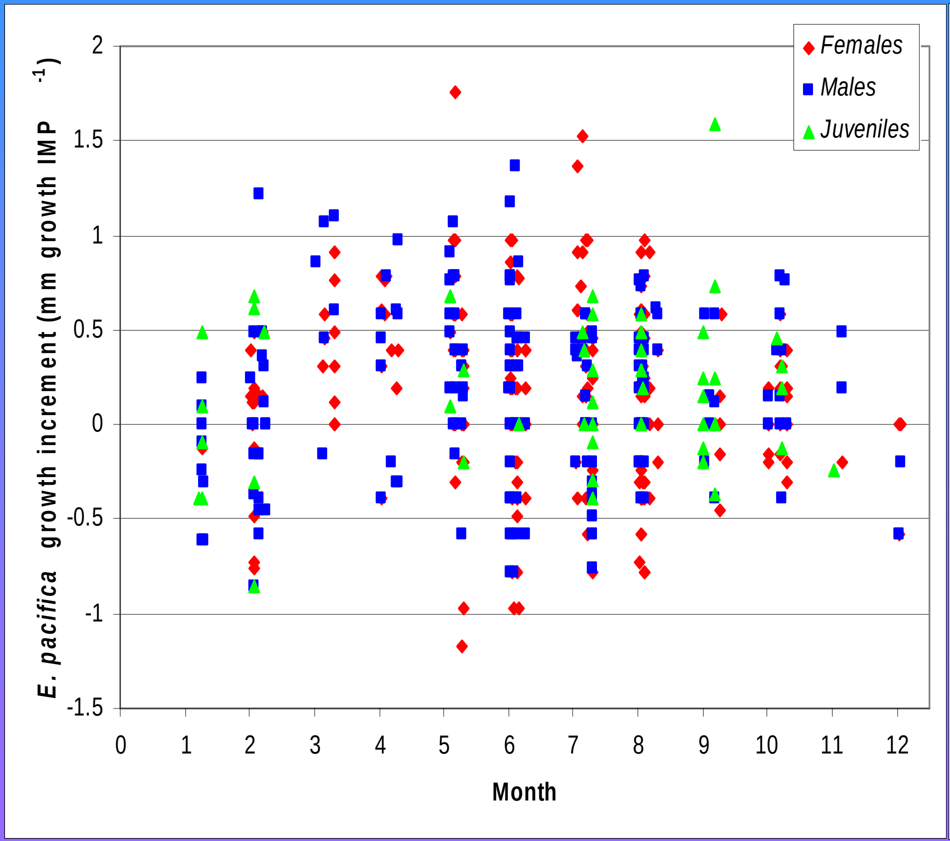
Comparison of experiment and cohort rates by month and season

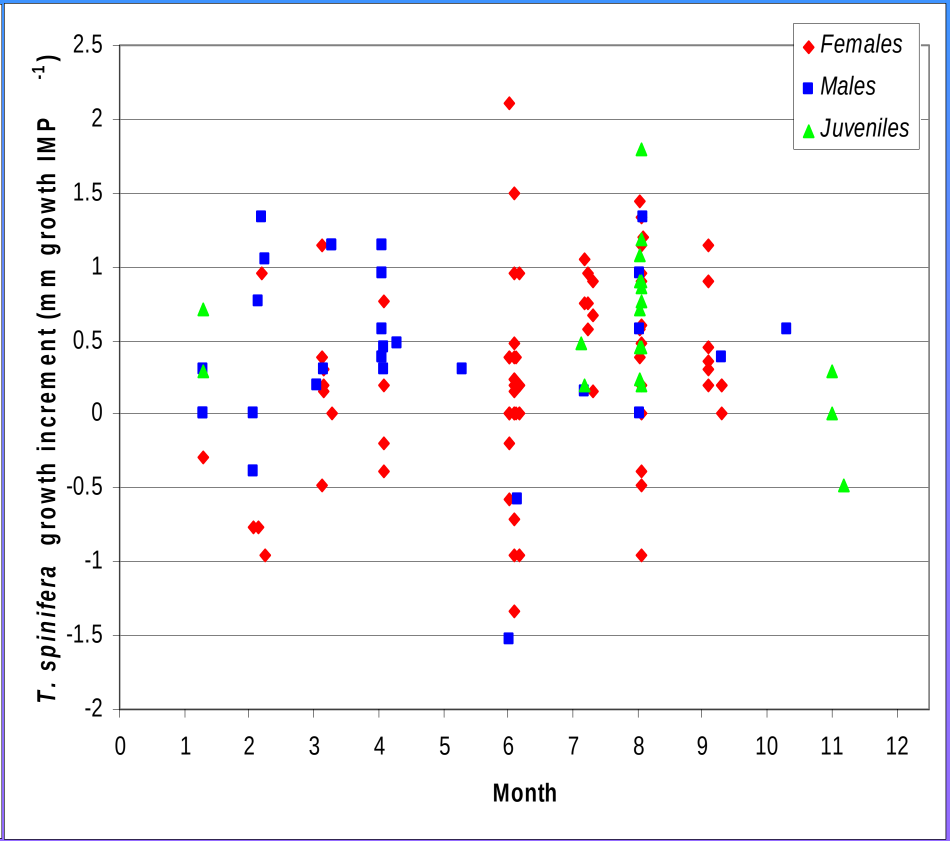


Euphausiid length frequency at NH25



Growth increments





Target Species

Generally found at and beyond the shelf break (>200 m depth)

Generally found on the shelf (<200 m depth)

Background Information

- May live up to 2 years
- Adult *T. spinifera* heavier than adult *E. pacifica* (mgC for a 20mm animal Ep≈6, Ts≈9)
- Euphausiids often >50% of zooplankton biomass in our study area
- Molt regularly throughout their life: may stay the same size, grow, or shrink (negative growth) at each molt, thus size not a good indicator of age